Series 1933, No. 9 Issued October, 1937

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

Boyd County, Nebraska

By

W. J. MORAN, in Charge, and F. A. HAYES
United States Department of Agriculture

and

R. H. LOVALD
Nebraska Soil Survey

Bureau of Chemistry and Soils

In cooperation with the
University of Nebraska State Soil Survey
Department of the Conservation and Survey Division

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SOIL SURVEY OF BOYD COUNTY, NEBRASKA [1]

By W. J. MORAN, in Charge, and F. A. HAYES, United States Department of Agriculture, and R. H. LOVALD, Nebraska Soil Survey

COUNTY SURVEYED

Boyd County is in northern Nebraska adjoining South Dakota (fig. 1). Butte, the county seat, is in the central part, about 120 miles northwest of Sioux City, Iowa. The county is roughly rectangular, and its southern and northeastern boundaries are Niobrara and Missouri Rivers, respectively. The land area of the county comprises 535 square miles, or 342,400 acres.

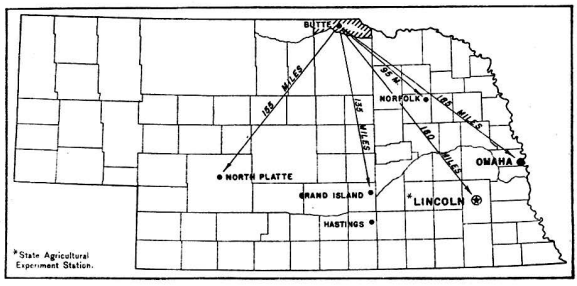

FIGURE 1.—Sketch map showing location of Boyd County, Nebr.

Boyd County is in the High Plains section of the Great Plains physiographic province. It is a part of a former nearly level to hilly constructional plain, which was subsequently severely eroded by the Missouri and Niobrara Rivers and their tributaries. Nearly level to moderately hilly remnants of the old plain still occupy about one-half of the county as numerous divides of various sizes and shapes between drainageways. The largest and most nearly level of these are on either side of Ponca Creek westward from Bristow and north of Keya Paha River in the northwestern part of the county.

Most of the smoother plain remnants are capped by a mantle of loesslike material, which is thinner but otherwise similar to the loess covering in sections of Nebraska to the south and east. Some of these remnants, including a few square miles southeast of Butte and small bodies in the northern and western parts of the county, are capped by sand or gravel. Most of the coarse-textured material reached its present position as inwash from sections to the north and west, but part of it has developed, through the processes of weathering, from Tertiary sandstone which outcrops here and there in the western part of the county. The sand and gravel lying next

[1] Report written by F. A. Hayes.

below the loess are exposed in places where erosion has removed the loessial cover.

In addition to the loess- and sand-capped remnants of the old plain are numerous areas of nearly level to moderately hilly upland on the Pierre shale formation. The largest and smoothest of these are north of Ponca Creek in the eastern part of the county, but smaller bodies with strongly rolling to moderately hilly relief are south of Ponca Creek in Lynch and Bush Townships and scattered throughout the north-central and northwestern parts of the county. The uplands on Pierre shale are from 50 to 150 feet below the general level of those capped by loess and sand.

The remainder of the uplands, comprising about 35 precent of the area of the county, is mostly on severely eroded Pierre shale and is extremely rough and broken. The rough land occurs as broad and narrow strips on the valley sides and adjacent uplands along all the larger and many of the smaller drainageways. The broadest and most continuous strips are along Missouri, Niobrara, and Keya Paha Rivers; those along the Missouri in places attain a width of more than 3 miles. Narrower though fairly continuous strips are along Ponca Creek throughout its course across the county and along most of the tributaries to this stream. In the rough and broken areas geologic erosion has carved the Pierre shale into a series of narrow valleys and sharp divides. Vertical exposures occur in few places, except bordering stream channels, but practically all of the land is steeply sloping. Differences in elevation in many places in the rough land bordering the Missouri and Niobrara Rivers exceed 200 feet within a distance of 100 rods. The slope is less abrupt along most of the other drainageways, but differences in elevation commonly exceed 100 feet within a 40-acre field, even along tributaries to Ponca Creek.

Scattered almost vertical exposures of Niobrara chalk rock, which is the lowest exposed formation in the county, are near the base of slopes bordering the alluvial land along Missouri River.

Alluvial land, including the terraces and flood plains, occupies about 15 percent of the county. The terraces, or benches, are the most extensive, and they occur at different elevations. The highest and one of the oldest benches lies from 90 to 120 feet above Niobrara River and occupies most of the area between that stream and Keya Paha River in the southwestern part of the county. This bench is sandy, and over most of its formerly smooth surface the terrace aspect has been obscured by low swells, ridges, and hummocks of wind-blown sand. The other terraces are broken strips, ranging from one-eighth to about one-half mile in width, chiefly along Niobrara River and Ponca Creek. They are composed largely of silt or clay, have nearly level relief, and lie from 15 to 30 feet above the stream channels.

The flood plains or bottom lands are from 3 to 8 feet above the streams and comprise the lowest land in the county. Adjacent to the larger stream channels, they occur as broken or continuous strips ranging from a few rods to about three-fourths of a mile in width. The strip along Missouri River is the widest, but it is only a few miles long. The bottom lands are, for the most part, flat but are

modified here and there by overflow channels, slight elevations, and slight depressions.

The average elevation of the county is about 1,650 feet. The lowest point, approximately 1,250 feet, is where Missouri River crosses the eastern boundary and the highest, about 2,000 feet, is on the uplands northwest of Naper. The altitude [2] at Butte is 1,798 feet above sea level, at Anoka 1,638.5 feet, at Spencer 1,541.5 feet, at Lynch 1,400.5 feet, and at Monowi 1,322.5 feet. The prevailing slope is to the east.

Drainage is in a general eastward direction through streams flowing into Missouri River. The drainage pattern is dendritic (treelike). All the streams have steep gradients and are actively deepening their channels. Niobrara River is slowly entrenching, but Missouri River falls only about 6 inches to the mile, is rather sluggish, and is filling its channel in places. Over much of the county, run-off is rapid and erosion is severe. The only poorly drained land occupies small and scattered basinlike depressions on the more nearly level parts of the uplands and a few spots on the bottom lands.

The quality, depth, and supply of well water varies in different localities and depends largely on the character and thickness of formations above the impervious Pierre shale which is noted for the scant supply and poor quality of its water. Throughout most of the loess-capped uplands, an abundant supply of good water is in the sands and gravels immediately beneath the loess and is reached at depths ranging from 50 to 250 feet. Where the sandy beds are thin and the Pierre shale rises above the water table, wells may be either dry or have only a small supply of alkaline water. Where the sandy strata are unusually thin or absent, as in most places in the eastern one-fourth of the county and for short distances back from the major drainageways in the central and western parts, difficulty is experienced in obtaining good water from upland wells. In these localities many of the farmers have tubular wells, most of which are between 400 and 700 feet deep. The water from these wells generally is abundant and, although slightly alkaline in many places, is more palatable than that obtained from shallow wells. Some farmers on the Pierre shale uplands obtain water for livestock and family use from ponds made by damming small draws or gullies.

In the alluvial land most of the wells range in depth from 10 to 90 feet, depending on the thickness of the alluvial deposits. They generally furnish an abundance of water, the purity of which depends on the distance from the Pierre shale.

Several springs are on the lower valley slopes along the rivers and Ponca Creek. Most of them issue from the contact zone between upland or terrace sands and the underlying Pierre shale. Spring water is in general of good quality.

The vegetation consists predominantly of grass. In virgin areas throughout the uplands and terraces, the principal grasses on the finer textured soils are little bluestem, grama, buffalo grass, and wheatgrass. On the more sandy soils big bluestem and needlegrass predominate in most places. The bottom lands support a variety of

[2] CONDRA, G. E. GEOLOGY AND WATER RESOURCES OF A PORTION OF THE MISSOURI VALLEY IN NORTHEASTERN NEBRASKA. U. S. Geol. Survey Water Supply Paper 215, 59 pp., illus. 1908.

moisture-loving grasses, except in a few poorly drained situations where only rushes and sedges grow.

Native forest, including elm, ash, bur oak, hackberry, boxelder, cottonwood, and willow, occupies narrow strips adjacent to stream channels in all the larger valleys, and trees are numerous on the lower slopes of bluffs bordering the bottom lands along Missouri River. The main use of the trees is for posts and fuel.

The first permanent settlements in the area now included in Boyd County were made along Keya Paha River about 1880, in what was then a part of Dakota Territory. The area was annexed to Nebraska in 1882, and Boyd County was established and organized in 1891. People of German or Bohemian descent formed a large proportion of the early settlers.

According to the Federal census there were 605 inhabitants in this county in 1890, 7,332 in 1900, 8,826 in 1910, 8,243 in 1920, and 7,169 in 1930. All the population is classed as rural, and there is an average of about 13.4 persons to each square mile. The population is densest in the towns, broader stream valleys, and loess-covered parts of the uplands. The rough and broken areas along Missouri and Niobrara Rivers are sparsely settled.

Butte, the county seat, with a population of 569, and Spencer, the largest town, with a population of 653, are about 10 miles apart in the central part of the county. Lynch with 498 inhabitants is in the southeastern part. Smaller towns and villages, including Naper, Anoka, Gross, Bristow, and Monowi, are located in different sections of the county and furnish local markets and distributing centers for farm supplies and produce.

Boyd County has fair transportation facilities. The Chicago & North Western Railroad (Wood Branch) from Norfolk, Nebr., to Winner, S. Dak., follows the valleys of Ponca and Dry Creeks. All the towns, except Butte, Naper, and Gross, are on this railroad. United States Highway No. 281 passes through the central part of the county in a general northwest-southeast direction, touching Butte and Spencer. State highways, surfaced with gravel, cross the county in east-west and north-south directions. The county roads are of earth construction but are kept in good repair. They follow section lines except in the rougher sections where they conform to the topography. Bridges cross Niobrara River south of Lynch, Spencer, Butte, and Naper.

All sections are served with rural delivery of mail. Telephones are in common use, and the public-school system is well developed.

CLIMATE

The climate is continental and is similar to that in other counties of north-central Nebraska. The summers are hot and the winters are long and cold. The spring is usually cool with considerable rainfall, and the fall season is long with only occasional periods of rainy weather. There is not enough variation in relief or elevation to cause appreciable differences in the climate in different sections.

Table 1, compiled from the records of the United States Weather Bureau station, at Butte in the central part of the county, gives the normal monthly, seasonal, and annual temperature and precipitation.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Butte, Boyd County, Nebr.*

[Elevation, 1,900 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	22.8	72	−29	0.59	0.57	0.58	6.4
January	19.2	69	−36	.47	.94	1.16	5.3
February	23.5	71	−31	.70	.12	4.04	8.0
Winter	21.8	72	−36	1.76	1.63	5.78	19.7
March	35.3	92	−17	1.08	.09	2.37	7.9
April	48.0	99	5	2.49	1.20	3.06	3.6
May	58.3	98	14	3.23	1.48	5.74	.2
Spring	47.2	99	−17	6.80	2.77	11.17	11.7
June	68.9	108	35	3.95	2.37	7.56	0
July	74.7	112	40	2.82	3.02	8.42	0
August	72.5	106	30	2.31	1.02	1.72	0
Summer	72.0	112	30	9.08	6.41	17.70	0
September	63.5	102	23	2.16	1.12	3.21	(1)
October	51.0	97	2	1.69	.35	1.95	2.3
November	36.1	84	−10	.70	.20	.33	3.2
Fall	50.2	102	−10	4.55	1.67	5.49	5.5
Year	47.8	112	−36	22.19	12.48	40.14	36.9

[1] Trace.

In average years about 76 percent of the precipitation falls during the principal part of the growing season, April to September, inclusive. The summer rainfall usually comes as heavy thundershowers, but torrential rains are rare. Severe droughts seldom occur during May and June, but late in July and throughout August short dry spells are common. In the latter months crops may suffer considerably from lack of moisture, especially on the more clayey soils. During dry weather these soils do not release enough moisture for most crops and have a tendency to shrink and crack, with consequent injury to the crop roots. In 1934 and again in 1936 very severe droughts greatly reduced the acreage and yields of crops in this county.

The average date of the last killing frost is May 6 and of the first is October 3. This gives an average frost-free season of 150 days which is ample for maturing all the farm crops commonly grown. During the 20 years from 1895 to 1914, however, there were three times when killing frost occurred 10 or more days later in the spring and more than five times when it occurred 10 or more days earlier in the fall, than the average date. Killing frosts have been recorded as late as June 10 and as early as September 15.

From about October 1 to April 1 the prevailing wind is from the northwest, and from April 1 to October 1 it is from a southerly direction. Strong winds are common, but tornadoes are rare. Dust-storms occur in years of severe drought.

AGRICULTURE

The early history of agricultural development in Boyd County is, in a general way, similar to that in most counties of north-central Nebraska. Prior to the first permanent settlements, which were made following the establishment of Fort Niobrara to the west in 1880, the area now included in this county was inhabited chiefly by trappers and hunters. The earliest settlers were few—most of them cattlemen who were attracted to the country by the luxuriant growth of native grass. The range was free, and cattle raising was very profitable. After completion of the railroad surveys about 1891, immigration was greatly stimulated. By 1900, most of the land had been homesteaded in tracts of 160 acres. The railroad, completed in 1902, brought additional settlers, and during the next few years the county had a larger population than at any other time in its history.

Most of the later settlers located in the rougher sections on land unsuited to cultivation and on tracts too small to be used profitably for grazing. After 1910, many of these settlers gave up their holdings and left the county. Those who remained purchased additional land. The result has been a slight decrease in the population and an increase in the average size of the farms during the last two decades.

According to the Federal census, there were 1,114 farms in the county in 1935, most of them ranging in size from 100 to 500 acres, the average size being 292.7 acres. There were 31 ranches containing 1,000 or more acres.

The farm buildings, as a rule, are moderately good. Most of the houses are one-story wooden structures, generally kept painted and in good repair. Barns and other outbuildings are generally large enough to house the crops, except hay, most of which is stacked in the field. The improvements average better throughout the more nearly level and for the most part loess-covered parts of the uplands than in the rougher sections of the county. Nebraska State agricultural statistics show that in 1930, 70 farmhouses had modern heating plants, 103 had running water, 81 were equipped with electricity, and 432 had radios. Farms and ranches are fenced and cross-fenced, generally with barbed wire, although many fields of corn and alfalfa are enclosed with hogtight woven-wire fencing. The work animals are heavy draft horses and mules, and some farmers use tractors and trucks for the heavier farm work. There were 203 tractors, 248 gas engines, 59 trucks, and 971 automobiles on the farms in 1930. The machinery is of the most modern and labor-saving types.

Farm labor during the last few years has been plentiful and unusually cheap. Monthly farm wages in 1933 ranged from $20 to $30, with board and lodging. Day labor was plentiful at $1 or $1.25. Corn shuckers received 2 or 3 cents a bushel. Only a few farmers hire help.

Nebraska State agricultural statistics show that owners occupied 41 percent and tenants 59 percent of the farm acreage in 1930. Of the acreage in tenant farms, 40 percent was rented for cash and the remainder for a share of the crop. Under the cash system of rental, the tenant pays from $2 to $4 an acre for the better grade farming land and from $60 to $100 a section (640 acres) for pasture. The average cash rent was about $2.25 an acre in 1930. Under the share

method of rental, the owner receives one-third of the grain and generally one-half of the hay, and all seed, labor, and machinery are furnished by the tenant. Many tenants pay a lump sum for the use of pasture land, and most of them give a share of the crop for the land devoted to hay.

The selling price of individual farms and ranches ranges widely, depending on the character of the soil, relief, drainage, improvements, and location with respect to markets.

The value of all crops produced in the county in 1929 was $2,196,058, and that of all domestic animals, poultry, and bees on farms, April 1, 1930, was $2,190,685. Cattle represent about 57 percent of the latter amount, horses, mules, and colts about 13 percent, and hogs about 24 percent. The remaining 6 percent represents the value of chickens, sheep, goats, and bees.

Table 2, compiled from the Federal census reports, gives the number and value of domestic animals and poultry in the county in 1900, 1910, 1920, 1930, and 1935.

TABLE 2.—*Number and value of livestock in Boyd County, Nebr., in stated years*

Livestock	1900		1910		1920		1930		1935
	Number	*Value*	*Number*	*Value*	*Number* [1]	*Value*	*Number* [2]	*Value*	*Number* [3]
Cattle	17,833	———	26,703	$635,887	30,562	$1,386,300	23,839	$1,251,274	20,859
Swine	32,331	———	33,833	314,393	41,771	775,950	42,951	540,517	7,813
Horses	7,822	———	9,919	1,059,319	8,595	599,387	6,443	259,552	5,001
Mules	398	———	492	56,335	540	50,232	596	32,316	433
Sheep	2,776	———	520	1,717	256	3,596	1,596	11,067	1,185
All poultry	[4] 74,108	$23,327	84,049	32,853	108,734	77,356	[4] 122,889	93,396	78,198

[1] On farms and ranges only.
[2] On farms and ranges Apr. 1, 1930.
[3] Number of livestock greatly reduced in 1935 due to drought and shortage of feed crops.
[4] Chickens alone over 3 months old.

The quality of the livestock in general is very good. The cattle are mainly grade animals, but most of the herds are headed by a purebred Hereford or Shorthorn bull. Most of the beef cattle are raised locally; some farmers annually ship in cattle for summer grazing; and a few purchase cattle from the Sioux City or Omaha markets for winter fattening.

Dairying is of minor importance; and, although most farmers keep from 3 to 10 milk cows, no farm is devoted exclusively to dairying. The cows milked are of mixed beef and dairy breeds. Surplus dairy products, chiefly cream, are sold on the local markets.

Nearly every farmer raises from 20 to 60 hogs, for the most part on corn and alfalfa. Barley and rye are sometimes added to the ration, and young pigs generally receive some oats. Many hogs are raised in connection with the feeding of beef cattle. All the hogs are of good breeding, and there are many herds of purebred animals. Duroc-Jersey, Poland China, and Hampshire are the leading breeds. Practically all hogs are fattened on the farms where raised and are sold in Omaha or Sioux City.

Sheep raising receives little attention. Some farmers on the better farming soils occasionally ship in a carload or two of sheep for fattening, and a few flocks of sheep are raised in the rougher and

more sandy parts of the county. No farm is continuously devoted to the raising or fattening of sheep.

Horse raising is confined chiefly to the breeding of work mares. Most of the horses are Percherons. Purebred stallions are kept on a few farms.

Chickens are raised on nearly all farms to supply the local demand for poultry products, and many farmers maintain flocks of several hundred. The principal breeds are Plymouth Rock, Leghorn, and Rhode Island Red. Turkeys are an important source of income on a few farms.

According to the Federal census, about 40 percent of the land in the county was cultivated, and about 9 percent was used for the production of wild hay in 1929. Most of the remaining 51 percent was included in native pasture. Of the cultivated crops, corn has occupied the leading acreage since farming began. Wheat ranked second in acreage until the late nineties, when the area devoted to oats was greatly increased and has since exceeded that in wheat during most years. The importance of wheat in the early agricultural development was due largely to the need for food and cash. As the farmers became better established, livestock became the most important source of revenue, and more feed was needed. Oats, being an important feed crop and well adapted to the soils and climate, were grown extensively at the expense of the wheat acreage, but considerable wheat is still grown. Other important crops are alfalfa, sweetclover, barley, rye, and sorgo. All these crops except wheat, which is grown chiefly for outside markets, is fed to livestock in the county.

Yields vary greatly from year to year, according to variations in the amount and distribution of the precipitation and the length of the growing season. They also vary widely on the different soils, but over the county as a whole average yields of the several crops are fairly uniform.

Table 3, compiled from census data, gives the acreage of the principal crops in the county during census years, and table 4, compiled from the Nebraska State agricultural statistics, shows the average acre yield of the more important crops during the 18-year period 1913 to 1930, inclusive, and the approximate percentage of the land devoted to each crop in 1930.

TABLE 3.—*Acreage of principal crops in Boyd County, Nebr., in stated years*

Crop	1899	1909	1919	1929	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Corn	46,260	64,858	65,634	78,902	3,626
Oats	5,912	33,946	16,054	32,089	5,865
Wheat	32,287	9,636	29,197	5,063	1,644
Rye	507	261	2,033	1,967	411
Barley	1,296	711	2,784	3,132	3,059
Potatoes	622	576	639	487	119
All hay	23,630	38,699	55,019	45,292	18,701
Wild hay	21,581	30,411	34,632	31,382	12,775
Timothy		566	171		
Clover		79	74	1,929	209
Timothy and clover		958	93	143	2
Alfalfa	28	4,308	13,540	10,718	1,750
Other tame grasses	1,973	1,487	2,185	1,013	
Grains and legumes cut for hay		790	356	107	3,965

[1] Acreage and production greatly reduced, owing to drought.

TABLE 4.—*Average acre yields of the principal crops in Boyd County, Nebr., from 1913 to 1930, inclusive, and percentage of total area occupied by them in 1930*

Crop	Average acre yields 1913 to 1930, inclusive	Area occupied by crop in 1930	Crop	Average acre yields 1913 to 1930, inclusive	Area occupied by crop in 1930
	Bushels	*Percent*		*Bushels*	*Percent*
Corn	23.7	23.0	Barley	24.8	0.9
Spring wheat	12.8	[1] 2.0	Potatoes	73.2	.1
Winter wheat	15.1			*Tons*	
Oats	29.5	9.3	Alfalfa hay	2.2	3.1
Rye	15.3	.5	Wild hay	.9	9.2

[1] All wheat.

Soil management and cropping practices are similar to those generally followed throughout northeastern Nebraska. Corn is planted in May, the greater part with a lister and the rest with a corn planter. Listed corn is thought by most farmers to be more drought resistant than checkrowed corn. The crop is cultivated three or four times during the season. It is usually "laid by" about the middle of July and receives no further attention until harvest. Corn matures in September or early October. Most of it is husked from the standing stalks, after which cattle and horses are pastured in the fields. On some farms part of the corn is cut for winter fodder. Many farmers annually fence off a few acres of unhusked corn for fattening hogs and cattle, thereby saving part of the expense of husking.

The seed corn is not, as a rule, carefully selected, although most of the seed used is from corn which has been grown in the locality for several years and has become adapted to local climatic and soil conditions. Corn generally follows small grains in the rotations, but it is often grown on the same land many years in succession with only a slight decrease in yields.

Practically all of the oats, which is the leading small grain, is of the early varieties. Kherson and strains of it, such as Nebraska No. 21, are the most extensively grown varieties. The land to be used for oats is usually disked and the grain is broadcast or sown with a press drill in March or early April. Yields are greater from the early-seeded oats. Oats generally mature in July and are cut with a binder or header, depending on the length of the stems. They are either shocked or stacked for threshing. This crop is seldom grown on the same land 2 years in succession, and it generally follows corn in the rotation. Most of the grain is fed on the farms where produced. The straw is almost as valuable as prairie hay for feeding and is stacked at threshing time.

Wheat is the chief cash crop. Most of it is of the spring varieties, chiefly Ceres and Marquis. A small amount of winter wheat, mainly Kanred and Turkey or improved strains of the latter variety, such as Nebraska No. 60, is grown. Spring wheat is planted in the same manner as oats, but winter wheat is seeded in the fall. Wheat ripens and is cut and stacked or shocked in July. Most of it is sold immediately after it is threshed.

The barley acreage, although still small, is steadily increasing. This crop ranks next to corn in terms of feed produced an acre. Feeding tests show that coarsely ground barley is 90 percent as good

as corn in a fattening ration. Most of the barley grown is of the smooth-bearded varieties, such as Comfort and Glabron. Practically all of the grain is fed on the farms where produced. Some barley is used as a nurse crop for alfalfa and sweetclover.

Rye is not an important crop. It is grown by a few farmers, usually for temporary fall and spring pasture, especially for brood sows and pigs. When grown for grain, it is seeded and harvested like winter wheat. Rye is a particularly good crop for sandy soil, and Rosen is the best variety for this county.

Alfalfa is the leading tame-hay crop. Nearly 11,000 acres were devoted to alfalfa in 1929, and this acreage could be profitably extended, especially on the soils of the terraces and bottom lands. The seed is usually broadcast on plowed, disked, and harrowed stubble land early in the spring, often with oats or barley as a nurse crop. Nebraska-grown seed is used ordinarily. Alfalfa is cut three times during the summer. A field of this crop is allowed to remain as long as the yield is satisfactory, usually 5 or 6 years. Corn or sorghum cane generally follows alfalfa in the rotations.

The use of sweetclover has increased remarkably during the last 10 years. This plant is a biennial and dies at the end of the second year, after producing seed. It is used chiefly for pasture and to some extent for hay and seed. When hay is desired, the crop is cut during the first year before the growth becomes coarse. The second year the crop may be allowed to mature and reseed itself or it may be cut with a binder and threshed for seed. The seedbed is prepared and the seed is planted in the same manner as for alfalfa. Sweetclover has an unusually wide adaptation. It thrives on either comparatively wet or dry soils and on soils of heavy or light texture. It is very valuable for soil improvement, and most farmers on the uplands consider it more satisfactory for this purpose than alfalfa. The roots are large, and they decay rapidly at the end of the second year's growth. The crop not only adds organic matter to the soil but, in common with other legumes, has the power of extracting nitrogen from the atmosphere and storing it in its roots. It is a good soil binder and is especially valuable on steep slopes where erosion is severe. The crop is also of value for use on heavy impervious soils because its large roots, on decaying, leave an intricate network of channels and passageways which increase the friability and aeration of the soil.

Wild hay is an important crop because large areas of the heavier clay soils and of the more sandy soils are not suitable for grain or tame-hay crops. Big bluestem, little bluestem, wheatgrass, and grama are the leading hay grasses. The highest yields are obtained on soils of the alluvial lands, but the hay on the uplands grows less rank and has the highest feeding value. The hay is stacked in the field and hauled to the feed lots as needed. Practically all of it is fed to cattle and horses on the farms where produced. No commercial fertilizer is used. Barnyard manure is commonly applied with good results to grain crops, particularly wheat and corn. Legumes are grown to supplement barnyard manure, as the supply of manure on the average farm is too small to maintain the supply of organic matter in the soil.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [3] and its content of lime and salts are determined by simple tests. The drainage, both internal and external, and other external features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation are studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. In places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a map, but must be mapped as (4) a complex. There are areas of land, such as coastal beach or bare rocky mountain sides, which have no true soil; and these are called (5) miscellaneous land types.

The most important of these groups is the series which includes soils, having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus the series includes soils having essentially the same color, structure, and other important internal characteristics, and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus Norfolk, Hagerstown, Boyd, Miami, Houston, and Mohave are names of important soil series.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Boyd clay loam and Boyd silt loam are soil types within the Boyd series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping and because of its specific character is usually the soil unit to which agronomic data are definitely related.

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the "pH value." A pH value of 7 indicates precise neutrality, higher values alkalinity, and lower values acidity.

A phase of a soil type is a subgroup of soils within the type, which differ from the type in some minor soil characteristic which may, nevertheless, have an important practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type, there may be parts which are adapted to the use of machinery and the growth of cultivated crops and other parts which are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Boyd County range from moderately to highly productive of those crops to which they are suited, but they differ widely in crop adaptabilities, according to differences in their composition and surface features. All the soils, except the more sandy or gravelly ones of the uplands and terraces, contain an abundance of lime, and none appears deficient in this material for crop requirements.

The county is near the eastern margin of the Great Plains region of the United States, and nearly all of the soils that are not subject to severe erosion or are not developed on the most recently deposited stream sediments, have dark topsoils, owing to an abundance of black organic matter derived mainly from decayed grass roots. Erosion, however, is rapid over one-third of the county, and the decayed vegetation has been removed almost as fast as it has formed. Here the soils, except where formed on dark-colored shales, are prevailingly light in color. Geological formations ranging from heavy shales to coarse sands and gravels are exposed in spots and over large areas, and soils on the same farm may show marked contrasts in texture. Differences in the degree of erosion and in the character of the underlying formations have also produced variations in the structure, compaction, and chemical composition of the soils. It is necessary for farmers in nearly all parts of the county to adjust their farming systems to local soil conditions if they are to receive the largest returns. Under the present system of farming the greater part of each soil is used in growing feed or pasture for livestock. Enough wheat is grown on a part of the finer textured soils of the uplands and terraces to furnish ready cash, but the acreage in this crop is less than that in either corn or oats.

Throughout the uplands, which occupy about 85 percent of the county, the soils owe many of their important characteristics to the

geological formations from which they have developed. Soils developed from light-colored limy and silty loess, covering most of the more nearly level uplands in the central and western parts of the county, are, with few exceptions, friable throughout, rich in organic matter and lime, and have high moisture-holding capacity. These are the most productive soils on the uplands for all the crops commonly grown, but they are used chiefly for corn and oats.

The sandy or gravelly soils on the uplands, most of which are in the western part of the county, are suited topographically to cultivation, but most of them are rather low in lime and organic matter, more or less droughty and unstable, and are used mainly for native pasture or hay land. Some of them are well supplied with organic material, are fairly retentive of moisture, and return good yields of corn, rye, and sweetclover, except in the driest years.

The soils that have developed from heavy Pierre shale, so extensively distributed throughout the uplands in the eastern part of the county and on valley slopes in the central and western parts, retain water well, but most of them have a high wilting coefficient,[4] shrink and crack badly in dry weather, owing to the high content of clay, and are difficult to cultivate, except under the most favorable moisture conditions. In addition, much of the area occupied by these soils is hilly or extremely rough and broken and the soils and shales contain more or less selenium which in some places produces poisonous vegetation.[5] They are used chiefly for pasture. In many nearly level or gently sloping areas, soils developed on Pierre shale have become so mixed with silt or sand that they are now markedly friable, easy to cultivate, and almost as productive as soils which have developed on loess.

The soils of the terraces and flood plains, although much less extensive than those of the uplands, are fully as variable. They have developed from different sediments washed from the adjacent uplands or from areas farther upstream and deposited in the valleys. Soils developed from sandy sediments are coarse textured throughout. Those on the terraces are rather unstable and are used largely for native hay and pasture land. Those on the bottom lands are well supplied with moisture and, except locally, where they are of such recent origin as to be practically devoid of organic matter, are excellent soils for the growing of corn and alfalfa.

All the finer textured soils of the terraces and flood plains are highly productive, but they differ considerably in their tillage requirements. The more silty ones can be cultivated under a rather wide range of moisture conditions, but those that have developed from shaly sediments washed from the Pierre formation, are difficult to handle, except under the most favorable moisture conditions, on account of their high content of clay. In general the finer textured soils on the terraces give larger yields of all crops than any of the soils on the uplands. The fine-textured soils of the bottom lands are a little too moist during most years for high yields of small grains, but give some of the largest yields of corn and alfalfa. They occupy only a small total area and frequently occur in strips too narrow for profitable farming.

[4] Maximum percentage of water in the soil when plants wilt from lack of moisture.

[5] BYERS, H. G. SELENIUM OCCURRENCE IN CERTAIN SOILS IN THE UNITED STATES WITH A DISCUSSION OF RELATED TOPICS. U. S. Dept. Agr. Tech. Bull. 482, 48 pp., illus. 1935.

This report groups the individual soils of the county on the basis of the crops for which they are most extensively used and for which they give the largest returns under the present farming systems, as follows: (1) Soils suitable for the production of corn and oats, (2) soils suitable for the production of corn and alfalfa, and (3) soils well suited only to grass. This grouping is not intended to imply that the crops mentioned in connection with a particular group are the only ones which can be or are produced on the soils of that group. All crops common to the climate can be successfully grown on the soils here classed as best adapted to corn and oats. In fact these soils might as well be called general farming soils, provided this term is held to mean that they are well suited to a system of general farming including the growing of all crops adapted to the climate. They are used and needed chiefly, however, for growing corn and oats, which are essential to livestock raising, on which the county largely depends. Under a more intensive farming system involving, where necessary, artificial drainage, incorporation of organic matter, and control of wind and water erosion, most crops adapted to the climate probably could be successfully grown on all the soils. Even under the present system, most of the crops can be grown on nearly all of the soils, except those topographically unsuited to cultivation or extremely sandy or gravelly. Larger returns are obtained, year in and year out, however, from the soils of a particular group when those soils are used for the crop or crops for which they are best suited. The grouping here used is based not only on soil and crop adaptations but also on those soil characteristics which are responsible for these adaptations and on the surface features and drainage conditions of the soils. The soils included in the several groups are not confined to particular sections, but some soils in each group occur in small areas surrounded by soils of other groups.

In the following pages the various soils in the different groups, are described and their suitability to different crops is discussed. The soil map accompanying this report shows the distribution of the soils in the county, and table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Boyd County, Nebr.*

Soil type	Acres	Percent	Soil type	Acres	Percent
Moody silt loam	63,488	18.6	Cass loamy fine sand	6,848	2.0
Moody very fine sandy loam	24,000	7.0	Cass fine sandy loam	8,896	2.6
Moody fine sandy loam	18,752	5.5	Sarpy silt loam	1,472	.4
Marshall loam, sandy-substratum phase	5,632	1.6	Lamoure very fine sandy loam	4,032	1.2
Marshall loamy sand, sandy-substratum phase	1,088	.3	Lamoure clay loam	2,048	.6
Boyd clay loam	19,584	5.7	Rough broken land	102,400	29.9
Boyd clay loam, light-colored phase	1,984	.6	Thurman sandy loam	5,824	1.7
Boyd silt loam	5,376	1.6	Thurman loamy sand	9,280	2.7
Boyd sandy loam	1,344	.4	Valentine sand	7,104	2.1
Holt very fine sandy loam	6,592	1.9	O'Neill loamy sand	6,848	2.0
Thurman fine sandy loam	16,832	4.9	O'Neill gravelly sandy loam, upland phase	896	.3
O'Neill fine sandy loam	704	.2	Holt loamy sand	640	.2
Hall very fine sandy loam	2,112	.6	Butler silty clay loam	1,920	.6
Verdel clay loam	8,896	2.6	Sarpy sand	1,600	.5
Verdel very fine sandy loam	3,584	1.0	Riverwash	1,088	.3
Verdel loamy sand	1,536	.4	Total	342,400	

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND OATS

This group includes all the Moody, Marshall, Boyd, Hall, and Verdel soils, and the less sandy types of the Holt, Thurman, and O'Neill series, making a total of 16 individual soils. All are in the uplands except the Hall, the Verdel, and some of the O'Neill soils, which are on terraces. Together these soils cover about 53 percent of the land area of the county.

There is considerable variation in the surface features of the different soils of the group. All the soils of the terraces and the Marshall and Moody soils of the uplands have nearly level or gently undulating relief. The Thurman and Holt soils are gently rolling, as a rule, whereas the Boyd soils range from nearly level to strongly rolling or hilly. In the smoother situations the soils have accumulated an abundance of organic matter and have very dark or almost black surface layers ranging from 10 to 15 inches in thickness. On slopes and hillsides these layers are thinner and lighter colored and in many places are deficient in organic matter. All soils in this group are well drained. With the exception of some of the Verdel and Boyd soils, which are composed largely of clay and are rather difficult to handle, they are friable throughout. Aside from the Thurman and O'Neill soils, which have sandy subsoils and are only moderately retentive of moisture, all have high moisture-holding capacities.

These soils, although not equally productive, are adapted to any crop commonly grown here. Few of them are as productive of corn and alfalfa as the best soils of the bottom lands, but they are better adapted to a wider variety of crops than those soils and are more productive of crops than any of the soils of the uplands or terraces not belonging to the group. Practically all of the area occupied by them is suited to the use of farm machinery, and about 80 percent of the land is cultivated. A part of the remainder is used for feed lots and building sites, but most of it is in native pasture or hay land. Corn occupies about one-half and oats about one-fourth of the cultivated land, and most of the rest is used for sweetclover, alfalfa, barley, sorgo, and rye, ranking in acreage during most years in about the order named.

Crop yields on the different soils of this group are fairly uniform in seasons of heavy precipitation, but they vary considerably in normal seasons and widely in dry years. In the wettest years the fine-textured Hall soil of the terraces is the most productive but is followed closely in productivity by the Moody and Marshall soils of the uplands. The sandy Thurman and O'Neill soils of the uplands and terraces, respectively, are more productive during unusually dry years than are the finer textured soils of the uplands. Except in the driest years the Boyd and Holt soils give higher yields than the Thurman or O'Neill soils, but they yield slightly lower than the Marshall or Moody soils in all years.

Moody silt loam.—Moody silt loam is by far the most extensive farming soil in the county, occupying 63,488 acres. It occurs on the uplands wherever the loessial mantle has not been removed by erosion or the silty texture of the loess formation has not been greatly altered by an admixture of wind-blown sand. The largest areas are

in the central part of the county, where the greater part of the smoother and higher lying upland is occupied by this soil. The relief ranges from nearly level to rolling. Both surface and internal drainage are everywhere thorough.

The 10- to 12-inch topsoil is friable silt loam which in most places is well supplied with organic matter and is very dark. On some slopes erosion caused by improper management has removed some of the dark material, leaving the soil with dark and light spots. The subsoil, which continues to an average depth of 4 feet, is dark grayish brown and slightly compact in the upper part but gradually becomes lighter in color and looser with depth, being almost white and very friable in the lower part. It consists largely of silt and is limy throughout. The upper part contains numerous small white lime concretions.

This soil as mapped in Boyd County, includes some variations from the typical soil as it exists in other counties; where in most places the subsoil is composed of silt to a depth below 10 feet. Nearly all of the Moody soils in this county are underlain by almost pure fine to coarse sand, at a depth ranging from 4 to 8 feet, and in some places this sandy material is much nearer the surface of the ground. In areas where pure sand is within a depth of 3 feet, the overlying silty material generally contains a small admixture of sand even up to the surface, and the soil does not contain much lime although it is not deficient in lime for crop requirements. Where such areas are of sufficient size to warrant locating, they are shown on the map as Marshall loam, sandy-substratum phase, instead of Moody silt loam. Many patches of the Marshall soil, too small to show legibly on a map of the scale used, are included with Moody silt loam. Also included are a few small patches of Moody very fine sandy loam, especially around the margins of the areas where wind-blown sand from more sandy soils has slightly coarsened the texture of the topsoil.

Practically all of Moody silt loam is under cultivation or occupied by building sites and feed yards. About one-half of the cultivated land is used for corn and about one-fourth for oats. The rest is used for alfalfa, sweetclover, barley, wheat, rye, and forage crops, all of which are grown more or less extensively on most farms.

Corn yields on this soil average considerably higher than those of the county as a whole. They equal or exceed the yields obtained from any other soil of the uplands, but they are slightly lower than those obtained from the finer textured soils of the terraces where the supply of moisture is more plentiful. Yields, especially of corn and alfalfa, are also lower than on most of the soils of the bottom lands where the ground water in most places is within reach of the corn and alfalfa roots. Moody silt loam returns higher yields of all crops than any of the sandy soils on terraces, however, and during some years returns higher yields of small grains than any soil on the bottom lands. The average yield of corn over a period of years is about 25 bushels an acre, oats 25 bushels, wheat 13 bushels, barley 18 bushels, rye 12 bushels, and potatoes 80 bushels. Alfalfa yields about 1.4 tons an acre during the first 4 or 5 years, after which yields decline. As on nearly all upland soils in Nebraska the alfalfa roots exhaust the supply of moisture in the subsoil and substratum, and

in this section alfalfa cannot make optimum growth on the moisture supplied by precipitation alone. The average yield of sorghum for fodder is about 2.5 tons an acre and that of sweetclover for hay about 1.3 tons.

Moody silt loam is easily handled, and moderate care in rotation of crops maintains its high productivity. It can be cultivated under a fairly wide range of moisture conditions. Clods are formed if the land is plowed when wet, but the lumps are reduced easily by subsequent tillage.

Moody very fine sandy loam.—Moody very fine sandy loam differs from Moody silt loam only in that its topsoil contains a little more very fine sand. The content of very fine sand, although sufficient to make this soil slightly easier to handle than Moody silt loam, especially when both soils are moist, does not noticeably reduce its water-holding capacity. The surface features are similar to those of Moody silt loam, and the soil is about as productive.

Moody very fine sandy loam is much less extensive than Moody silt loam. There are a few large and several small bodies on the more nearly level areas of the loess-covered uplands in nearly all parts of the county. One of the largest areas—about 10 square miles—is in the vicinity of Gross in Morton Township. Smaller bodies are in McCully, Basin, Spencer, and Lynch Townships. The soil is adapted to all the crops commonly grown, and practically all of it is under cultivation. It is regarded equal to Moody silt loam for general farming.

Moody fine sandy loam.—Moody fine sandy loam resembles the other Moody soils, in that it is developed largely from loess, has a well-developed dark topsoil rich in organic matter, and has an abundance of lime in its subsoil. It contains more and a slightly coarser grade of sand in both topsoil and subsoil. The content of fine sand, although not sufficient to alter appreciably the moisture-holding capacity of the soil, slightly impairs its stability. Crop yields over a long period of years do not average quite so high as on the finer textured Moody soils. The soil is adapted to all the crops commonly grown, however, and is almost as productive as Moody silt loam.

This soil occupies many, though generally small, bodies in all parts of the loess-covered uplands. One of the largest, comprising about 2,000 acres, is southwest of Spencer, and one of about the same size is southwest of Butte. Most of the others cover less than 600 acres each. Practically all of the soil is under cultivation and is used for the same crops as are grown on Moody silt loam.

Marshall loam, sandy-substratum phase.—Marshall loam, sandy-substratum phase, occupies only a few areas, the largest of which covers several square miles on a high loess-capped divide between Keya Paha River and the headwaters of Ponca Creek, in the northwestern part of the county. The relief is nearly level or gently undulating, except here and there in the vicinity of drainageways, where it may be steeply sloping. All the soil has good surface and internal drainage, and practically none of it is subject to severe erosion.

The topsoil ranges from 8 to 12 inches in thickness and is very dark. It contains a moderate amount of fine sand and medium sand

and a few pebbles, but it is composed largely of silt which, together with an abundance of organic matter, makes the soil stable against wind erosion. The subsoil, which consists of slightly sandy silt, is brown in the upper part and light yellowish brown or gray in the lower part. It is underlain by loose gray sand or a mixture of sand and gravel at a depth ranging from 26 to 36 inches. This soil contains much less lime than the Moody soils, but it is not deficient in that material for crop requirements.

Owing to the fairly high content of sand and the rather slight depth to the underlying sand and gravel, this phase of Marshall loam is not so retentive of moisture as are the Moody soils, and yields average slightly lower. The soil can be cultivated under a wide range of moisture conditions and returns good yields of all the crops commonly grown, except in the driest years. It is used for the same crops as are grown on Moody silt loam, and nearly all the land is under cultivation.

Marshall loamy sand, sandy-substratum phase.—Marshall loamy sand, sandy-substratum phase, occupies a few small areas chiefly between Keya Paha and Niobrara Rivers in the southwestern part of the county. The largest comprises about 640 acres.

The topsoil is composed largely of loose porous fine sand or medium sand. It contains an abundance of organic matter and is very dark to a depth ranging from 8 to 10 inches but is subject to wind erosion when under cultivation. The subsoil, beginning at a depth of about 14 inches, is light-gray floury silt or a silt and sand mixture. It does not contain much lime but, like the subsoil of the sandy-substratum phase of Marshall loam, seems to have enough for crop needs. At a depth of about 3 feet the subsoil is underlain by almost pure sand or sand and gravel, similar to the material underlying the corresponding phase of Marshall loam.

Owing to its greater content of sand, this soil is less retentive of moisture than the corresponding phase of Marshall loam or any of the Moody soils. It is not droughty, however, and, although not well adapted to small grains or alfalfa on account of its unstable topsoil, it is fairly well suited to corn, sweetclover, and forage crops. In average years these crops yield from one-fourth to one-half less on this soil than on Moody silt loam.

This soil is nearly level or gently rolling, and most of it is under cultivation, but, owing to its small extent, it is of little agricultural importance.

Boyd clay loam.—Boyd clay loam occurs in places where erosion has exposed the heavy Pierre shale formation to weathering and soil development but has not rendered the surface of the land too rough for cultivation. The largest areas are in Bristow, Lynch, and Bush Townships, and numerous narrow strips and small irregularly shaped bodies are scattered throughout the central and northern parts of the county.

Most of this soil occupies gradual or fairly steep valley slopes, and much of it extends over the round-topped divides between drainageways. The relief as a whole is strongly rolling or hilly. Surface drainage is everywhere well established, and over most of the soil run-off is rapid and sheet erosion is severe. Internal drainage is

good but slow, owing largely to the heavy clayey character of both topsoil and subsoil.

The topsoil, which consists of heavy silty clay loam or clay loam, ranges in thickness from a few inches to more than a foot, and in content of organic matter from very low to high, depending largely on the slope. It is much thinner and contains less organic matter on the steeper slopes than on the more gradual ones or on the broader divides. The upper part of the subsoil is largely clay. The lower part, beginning at a depth ranging from 30 to 40 inches, is a clay-shale mixture which gradually becomes more shaly with depth, giving way to the parent Pierre shale formation, in most places within a depth of 5 feet. The subsoil is very limy and is fairly friable because most of the lime occurs as fillings in an intricate network of seams and cracks, which gives considerable porosity to the otherwise almost watertight clay. The color ranges from light to dark, depending on the color of the underlying shale. In general the subsoil contains many rusty-brown splotches, streaks, and spots.

The color of the soil varies. In places where the land surface has favored the accumulation of much organic matter, the topsoil is dark or almost black. On the steeper slopes, where run-off is rapid and the content of organic matter is low, the color of the topsoil conforms rather closely to that of the parent shale. Over most of the county this shale is black or dark olive drab, but it includes several light-colored beds, some of which are thick. Where the steeply sloping Boyd soil is developed on the darker Pierre shale, its topsoil is dark, regardless of the severity of erosion, but where it is developed on light-colored Pierre shale, its topsoil is light gray or almost white. A few patches of the lighter colored soil are included with mapped areas of this soil as they were too small to separate. The larger of such areas are shown on the map as a light-colored phase of Boyd clay loam.

Although practically all of this soil is topographically suited to tillage, it is rather difficult to handle, except under the most favorable moisture conditions, and only about 50 percent of it is under cultivation. The cultivated land is used for the same crops as are grown on the Moody soils. In wet years crop yields are almost as high as on Moody silt loam, but in dry years they are low because the high content of clay causes the soil to shrink and crack, thereby breaking the crop roots and exposing them to drought. The uncultivated parts of the soil are used for native pasture and hay land. The native grasses will support a cow and calf on each 7 acres, or when cut for hay, will yield about one-third of a ton an acre. The hay is of good quality and consists largely of grama and western wheatgrass.

Boyd clay loam, like the other soils developed from Pierre shale, nearly everywhere contains small quantities of selenium. Hay, grain, grasses, or weeds grown on this soil store a greater or less amount of this toxic element and when consumed by livestock may cause a serious disorder, which erroneously has been called "alkali disease." A few farmers have sustained severe losses from selenium. The section of this report entitled "Selenium Poisoning" gives additional information on the subject.

Boyd clay loam, light-colored phase.—Boyd clay loam, light-colored phase, occupies numerous small areas scattered throughout the uplands in Lynch and Bush Townships. Most of them lie south of Ponca Creek. Two of the largest, comprising about 320 acres each, are in the vicinity of Lynch. None of the others exceeds 200 acres.

This soil differs from typical Boyd clay loam chiefly in that it has a lighter colored surface soil. It has developed from light-colored beds of the Pierre formation, whereas the typical soil has developed from the dark-colored beds. Soil of this phase has a strongly rolling to hilly relief, and it is typically developed on steep slopes and narrow divides. Only a negligible part of it, however, is too rough for cultivation.

The topsoil is gray or light-gray clay loam or silty clay loam ranging from less than 6 inches to about a foot in thickness, and it contains very little organic matter. In its virgin state the soil material is friable when dry or only slightly moist. It becomes extremely sticky and plastic when wet and, if cultivated in this condition, dries in hard lumps, which require subsequent wetting and drying before a friable condition is restored. The subsoil, where present, does not differ noticeably in texture from the topsoil but is generally slightly lighter in color or nearly white. It does not exceed 18 inches in thickness, except in a few places, and in most places is absent, the topsoil resting directly on light-gray Pierre shale. The soil is everywhere very limy, even at the surface.

Owing to its hilly relief and low content of organic matter, this soil is not extensively used for tame-hay or grain crops. Only about 40 percent of the land is cultivated. If carefully managed, however, all crops common to the section can be successfully grown. This soil does not shrink and crack so badly as Boyd clay loam during dry weather, and it is about as productive as that soil. The uncultivated areas are used for native hay and pasture land, for which they are about as well suited as is typical Boyd clay loam. The soil is of little agricultural importance on account of its small extent.

Boyd silt loam.—Boyd silt loam is one of the most productive soils on the uplands. Most of it occurs in Bush and Lynch Townships, although one of the largest bodies, comprising about 800 acres, is northwest of Anoka in McCully Township.

The soil has an undulating or gently rolling relief and good surface and internal drainage. It lies considerably below the general level of the Moody and Marshall soils, but only a negligible part is subject to severe sheet or gully erosion. It differs from Boyd clay loam chiefly in that it is much more friable, especially in the topsoil, and in having more nearly even relief. It is better supplied with organic matter than most areas of Boyd clay loam.

The topsoil, which ranges from 8 to 12 inches in thickness, is composed largely of silt and organic matter, is mellow, and is very dark throughout. The upper part of the subsoil, to a depth of about 30 inches, is friable or only moderately compact silty clay loam. In many places it is slightly lighter in color than the topsoil, but may range from very dark grayish brown to grayish brown. The lower part of the subsoil is compact silty clay loam or clay. It contains

very little organic matter and is light grayish brown, dark bluish gray, or almost black, depending on whether or not the underlying Pierre formation is light or dark. The unweathered shale lies at a depth ranging from 4 to 5 feet. The topsoil does not contain much lime, but the lower part of the subsoil and the parent shale are very limy.

This soil, although remarkably uniform throughout most of its distribution, varies somewhat in the thickness and color of its topsoil layer. On some low rounded knobs and hummocks the topsoil is rather thin, contains little organic matter, and is light in color, whereas in the sags adjacent to the knobs the topsoil is unusually dark and thick—in places more than 2 feet thick. These variations are of little agricultural importance, owing to their small extent.

Boyd silt loam is suitable and is used for all grain and tame-hay crops grown in the county. It is nearly as productive as Moody silt loam, and the farmers regard it as about equal to that soil for general farming. Practically all of it, aside from a small part used for building sites and feed yards, is under cultivation.

The value of this productive soil is seriously lowered by its content of a toxic element, selenium, which is taken up to greater or less extent by all kinds of vegetation. The so-called alkali disease, which results from feeding livestock poisonous hay and grain grown on this soil, has been reported from a number of farms. The heaviest losses from this cause have been on areas northeast of Lynch.

Boyd sandy loam.—Boyd sandy loam occupies many small areas in the uplands. The largest body, comprising about 250 acres, is about 6 miles northeast of Naper. Few of the other areas exceed 160 acres.

Most of this soil is within or near, and generally lower than, areas of more sandy soils. It has developed over Pierre shale, and the surface material has been mixed with wind- or water-transported sand to a depth ranging from 10 to 18 inches. The topsoil in most places has accumulated much organic matter and is dark grayish brown or very dark grayish brown to a depth of about 10 inches. The relief ranges from nearly level to gently sloping.

All the land is topographically suited to the use of farm machinery, and about 80 percent of it is under cultivation. The same crops are grown as on the Moody sandy soils. Yields average about 15 percent lower than on Moody silt loam. The sandy topsoil does not form a sufficiently compact seedbed for good yields of most small grains.

This soil has an unusually high moisture-storing capacity, because the porous sand in the surface layer rapidly absorbs all the precipitation and the underlying clayey shale prevents loss of moisture through seepage.

The cultivated part of this soil is used chiefly for corn, but some alfalfa and sweetclover are grown. The uncultivated part is covered with a luxuriant growth of needlegrass and big bluestem and has a higher value for pasture and hay land than any other Boyd soil, except Boyd silt loam. No area of Boyd sandy loam occupies an entire farm, and this soil is of minor agricultural importance in this county because of its small extent.

Holt very fine sandy loam.—Holt very fine sandy loam occupies several small areas in the uplands, mostly in the western half of the county. One of the largest, comprising about 600 acres, is southeast of Butte, and one occupying about 500 acres is north of Naper. Most of the remaining areas are less than 160 acres each.

This soil has developed from a light-colored soft limy sandstone which overlies the Pierre shale. In the eastern part of the county most of this sandstone has been removed by geologic erosion; in the western part it still extends over large areas, but the greater part is covered by loess or sand. Holt very fine sandy loam occurs only where the sandstone has been exposed to weathering and soil development.

The relief ranges from nearly level to rolling, the greater part of the soil occupying gently undulating areas. Surface drainage is well developed, and internal drainage is thorough but not excessive. The topsoil, which is well supplied with organic matter, is dark grayish brown or very dark grayish brown and ranges from 8 to 14 inches in thickness. In most places it is fine sandy loam, but in many localities it contains a little more and slightly coarser sand than is typical and approaches fine sandy loam in texture. It is mellow throughout. The upper part of the subsoil is brown mellow silt loam which gradually passes, at a depth of about 2 feet, into light grayish-brown friable or only moderately compact sandy clay loam. The light-colored limy sandstone in most places lies below a depth of 3 feet but in a few spots is much nearer the surface. The subsoil is very limy, especially in the lower part.

Aside from patches where the sandstone lies unusually near the surface, this soil gives only about 10 percent lower yields than Moody silt loam. It is well suited to all crops commonly grown, and about 75 percent of it, including all the larger bodies, is under cultivation. Corn, oats, and wheat, ranking in acreage in the order named, are the leading crops. Smaller and less accessible bodies and patches, where the sandstone lies at a slight depth, are used for pasture or hay land, for which they are well suited.

Thurman fine sandy loam.—Thurman fine sandy loam occupies areas of various sizes and shapes throughout the uplands in nearly all parts of the county. The largest areas are in Butte, McCully, and Basin Townships, where some of them exceed 1,200 acres.

The soil has developed from slightly silty sand which formerly was covered with loess but which was exposed when the loessial cover was removed. This soil, as a rule, occupies slightly lower positions than the Moody soils. The land ranges from nearly level to gently undulating. Drainage channels are not well developed, because practically all of the precipitation is rapidly absorbed by the porous sand.

The 8- to 12-inch topsoil is very dark grayish-brown fine sandy loam or very fine sandy loam. It contains an abundance of organic matter and silt and is not subject to destructive wind erosion even during prolonged periods of dry windy weather. The subsoil is composed largely of sand but contains sufficient silt and clay to bind the sand grains together loosely and to make the material fairly retentive of moisture. It is brown in the upper part from stains of organic matter leached from the topsoil but becomes lighter in color with depth and in most places is light grayish brown at a

depth ranging from 30 to 36 inches. Neither the topsoil nor subsoil contains much lime, but crops do not indicate a deficiency of lime.

Practically all of this soil is under cultivation. Most of it is used for corn, although all the crops commonly grown are produced on it. The soil can be cultivated under almost any moisture conditions without danger of puddling or blowing. It is one of the first of the soils used for general farming to warm in the spring and can be seeded to crops several days earlier than any heavier textured soil in the county. It is not quite so well supplied with plant nutrients as are the Moody soils, and crop yields average from 20 to 30 percent below those obtained on Moody silt loam.

O'Neill fine sandy loam.—O'Neill fine sandy loam is of little importance in the agriculture of the county as its total area is only 704 acres. It occupies a few small bodies, all of which are in the valleys along Ponca Creek and Keya Paha River, most of them along the former stream west of Anoka. The largest body comprises less than 200 acres.

This soil is similar to Thurman fine sandy loam in soil features and crop adaptabilities, but it occurs on stream terraces, whereas the Thurman soil is on the uplands. As a result of its lower position and consequently more favorable moisture supply, the O'Neill soil is a little more productive than most of the Thurman soil, but the difference is so slight that most farmers regard the two soils with equal favor. Practically all of O'Neill fine sandy loam is under cultivation.

Hall very fine sandy loam.—Hall very fine sandy loam occupies small scattered areas and narrow strips in the Ponca Creek Valley throughout its extent across the county. Two of the largest bodies, comprising about 160 acres each, are in the vicinity of Monowi and east of Spencer, and a rather long but narrow strip is north of Lynch along Whiskey and Silver Creeks.

This soil has developed from gray limy loess similar to that underlying the Moody soils of the uplands, but which was carried to its present position by streams and deposited along their courses when they were flowing at higher levels. Later entrenchment of the stream channels left the deposits from 8 to 20 feet above the present bottom lands. This material has been weathered, and a soil has developed with an accumulation of organic matter.

The relief is nearly level, but there is sufficient slope to afford ample surface drainage. Internal drainage is thorough but not excessive. None of the soil is subject to destructive wind or water erosion.

This soil is similar to Moody silt loam in most of its features and differs from that soil only in that it has a slightly thicker surface layer and occupies lower positions. The topsoil ranges from 14 to 18 inches in thickness. It is friable throughout and, owing to an abundance of organic matter, is very dark. In most areas the topsoil is very fine sandy loam, but in a few, including all those in Butte Township, the topsoil contains a little more fine sand than typical, approaching a fine sandy loam in texture. The upper part of the subsoil is brown or grayish-brown silt loam which is a little more compact than the topsoil but not nearly so dense as the corresponding layer of the Verdel soils, and it is easily penetrated by air,

moisture, and plant roots. The lower part of the subsoil, beginning at an average depth of about 30 inches and continuing to a depth below 6 feet, is light-gray floury limy silt. The soil is very retentive of moisture. It is remarkably uniform except for slight variations in the texture of its topsoil.

Hall very fine sandy loam is admirably suited to all crops grown in the county and is more productive than any other soil classed as suitable for the production of corn and oats. It is more favorably situated to receive run-off from higher levels than any soil of the uplands.

Practically all of the land is under cultivation. It is used for the same crops as are grown on Moody silt loam, although a slightly larger proportion is used for alfalfa than is similarly used on any Moody soil. Alfalfa yields as high as on any soil in the county, and corn and small grains yield higher than on any other soil. Hall very fine sandy loam is of little agricultural importance, however, on account of its small extent.

Verdel clay loam.—Verdel clay loam is the most extensive soil developed on terraces of the group of soils suited to corn and oats. It occurs in strips of various lengths and widths in the valleys of all the larger streams, except Missouri River. The widest and longest strips are in the Niobrara Valley, where they attain in places a width of more than one-half mile.

The terraces on which this soil is developed were formed in the same manner as those on which the Hall soil occurs, but they are composed largely of clay washed from upland areas of Pierre shale instead of silt from the loessial uplands. The relief, in common with that of nearly all terraces in the county, is nearly level with a gentle slope down the valley and toward the streams. Surface drainage is well established. Internal drainage, although adequate, is rather slow, owing to the fine texture of the soil.

The soil throughout is composed largely of dense clay, but it contains an abundance of lime, in the form of seams, streaks, and splotches, which somewhat reduces the compaction of the clay and makes the soil considerably more friable than it otherwise would be. The topsoil is very dark grayish-brown clay loam, silty clay loam, or clay, well supplied with organic matter. It ranges from 10 to slightly more than 22 inches in thickness. Below this the soil material is largely very dark bluish-gray clay. In places there are scattered rusty-brown streaks and splotches and a few small iron concretions.

Nearly all the land is under cultivation. During seasons of normal or heavy precipitation it is nearly as productive as Hall very fine sandy loam, but in dry years the high content of clay causes the topsoil to shrink and crack, thereby injuring plant roots and reducing crop yields. The soil is difficult to handle, except under the most favorable moisture conditions. If plowed when wet, hard lumps are formed, which require freezing and thawing or wetting and drying before granulation is restored. It is almost impossible to work the soil when it is extremely dry. Under favorable moisture conditions, good tilth is easily maintained. This soil is used for all the crops commonly grown.

Verdel very fine sandy loam.—Verdel very fine sandy loam resembles Verdel clay loam, except that its topsoil contains more sand and less clay. The soil occupies terraces similar to those on which Verdel clay loam is developed. It has about the same surface features and drainage conditions and is used for the same crops.

The topsoil is fine sandy loam or very fine sandy loam. It is more friable and can be cultivated under a much wider range of moisture conditions without danger of becoming cloddy than the topsoil of Verdel clay loam. Its high content of sand prevents shrinking and cracking during prolonged dry periods, and in seasons of low rainfall it generally returns higher yields of all crops than Verdel clay loam. It is considered nearly as productive as Hall very fine sandy loam, except in seasons of unusually low rainfall. The dense clay subsoil, although as well supplied with moisture as that of Hall very fine sandy loam, is unable to release as much of the moisture, and during prolonged dry spells crops suffer from drought much more than on the Hall soil.

Practically all of this soil is under cultivation. It occupies several small areas in the valleys of Niobrara and Keya Paha Rivers and Ponca Creek. The largest of these—about 500 acres—is on the north side of Niobrara River about 2 miles west of Whiting Bridge.

Verdel loamy sand.—Verdel loamy sand occupies a few small areas, chiefly in the Niobrara Valley in the southwestern part of the county. One of the largest comprises about 320 acres.

This soil occupies terraces similar to those occupied by the other Verdel soils. It is simply Verdel clay loam or Verdel very fine sandy loam, the surface of which has been covered to a depth ranging from 10 to about 20 inches by sand transported by wind or water. The topsoil is largely fine sand and medium sand and has lain long enough to have accumulated much organic matter. It is very dark to a depth of about 8 inches but is rather unstable, especially when brought under cultivation. The soil is highly retentive of moisture. The sandy topsoil rapidly absorbs all precipitation and the underlying clay prevents loss of moisture through seepage.

About 80 percent of the area occupied by this soil is used for corn and sweetclover, in the proportion of about 15 acres of the former to 1 of the latter. Some rye is grown, but the soil is too sandy and unstable for good yields of wheat or oats. Corn yields average about one-half as large as those obtained on Moody silt loam, except in seasons of high rainfall, when they are nearly as large as on the best soils of the uplands. Sweetclover does not seem to be adversely affected by the sandy nature of the topsoil and yields about four-fifths of a ton of hay an acre during average years.

The uncultivated parts of the soil support a luxuriant growth of needlegrass and big bluestem and are used for native hay and pasture land. No area of this soil covers an entire farm.

SOILS SUITABLE FOR THE PRODUCTION OF CORN AND ALFALFA

This group includes all the soils on the bottom lands in the county, except Sarpy sand which, on account of its extremely sandy and unstable nature and low content of organic matter, is included with the soils well suited only to grass. The group is much less extensive

than either of the other groups, occupying only 6.8 percent of the land area of the county. It includes five soils—those of the Cass and Lamoure series and Sarpy silt loam—which are among the most productive in the county for corn and alfalfa. One or another of them occurs in broken or continuous strips in the broader valleys, the largest developments being along Missouri and Keya Paha Rivers and Ponca Creek.

All soils of this group have nearly level relief, except where crossed by old and active stream channels or where modified here and there by slight elevations or depressions. Surface drainage, although rather slow, is well established, except in a few places. Much of the land is subject to overflow during periods of high water, but most of it lies from 3 to 8 feet above the normal level of the streams, and the water drains off within a few hours after the streams subside. The only poorly drained areas are in a few small depressions where the water is forced to seek outlet through seepage. The water table in the larger valleys is from 5 to 12 feet beneath the surface, and the lower part of the subsoil is well supplied with moisture even in the drier years.

All soils belonging to this group have developed from recently deposited stream sediments—the Cass and Sarpy soils from sandy sediments and the Lamoure from silty sediments. They are naturally better supplied with moisture than any soil of the uplands or terraces, because the precipitation received by them is supplemented by run-off from higher levels and by capillary rise from the underlying water table. The run-off from higher lands brings considerable organic matter and other plant nutrients to these soils, the moist conditions have favored a rapid growth and decay of vegetation, and all soils of the group except the Sarpy, which occurs on the most recently deposited sediments, have dark topsoils containing an abundance of organic matter.

About 70 percent of the area occupied by the soils of this group is under cultivation. The rest of the land, which occurs either in strips too narrow for profitable farming or in bodies too poorly drained for cultivation, is used for pasture or hay land or is covered by native forest. About 85 percent of the cultivated land is devoted to corn and alfalfa in the proportion of about 15 acres of corn to 1 of alfalfa. The rest of the cultivated land is used for oats, sweetclover, barley, sorgo, and millet, ranking in acreage in about the order named. All small-grain crops grow well on the soils of this group but have a tendency to produce a rank growth with long weak stems which break and lodge during windy weather. In addition, small grains generally mature late, and in wet years they yield rather low. The short stiff-stemmed varieties of oats yield fairly well, but even these varieties have a tendency to grow rank at the expense of the grain and are of minor importance on the soils of this group.

Cass loamy fine sand.—Cass loamy fine sand, although one of the more extensive soils of this group, occupies only 6,848 acres. It occurs in narrow continuous or broken strips in the bottom lands along Niobrara and Keya Paha Rivers and Ponca Creek.

The 8- to 10-inch topsoil consists chiefly of very dark grayish-brown loose medium sand or fine sand. It contains much well-de-

composed organic matter which imparts the dark color and loamy texture, but which is not present in sufficient quantities to prevent the soil from drifting during prolonged droughts. The subsoil is gray incoherent fine sand or medium sand, which in most places extends below a depth of 4 feet with little change, but which in places contains considerable coarse sand and gravel in the lower part. It is generally limy. It is low in organic matter and here and there contains scattered rusty-brown stains resulting from slow drainage.

This soil has developed from sandy alluvium of recent origin, deposited on the flood plains of the streams, and from sand blown out of the stream channels. Subsequent action of soil-forming processes and accumulation of organic matter has given the topmost layer of the sandy material a loamy texture.

Areas of this soil are flat, modified in places by low ridges and hummocks, composed of almost pure sand. Few areas are subject to overflow, and internal drainage is fair, except in a few places where, in wet years, the water table lies so near the surface as to produce marshy spots.

About 80 percent of the land is under cultivation. This is one of the least productive soils of the bottom lands, owing largely to its high content of sand and rather unstable nature. It returns nearly as high yields of corn and higher yields of alfalfa than any of the soils on the uplands, however, and is used mainly for these crops. The subsoil is too moist and the topsoil too unstable for optimum yields of small grains.

Uncultivated areas remain in native pasture or hay. They produce a luxuriant growth of big bluestem which in average years will support a cow or steer on each acre, or when cut for hay will yield about three-quarters of a ton an acre.

Cass fine sandy loam.—Cass fine sandy loam occurs in the bottom lands, generally in association with Cass loamy fine sand which it closely resembles. It differs from that soil only in that its surface layer, to a depth of 8 or 10 inches, contains less sand and more silt, clay, and organic matter and is consequently more stable. It is the most extensive soil in this group.

This soil is one of the most productive for corn and alfalfa in the county, and most of it is used for these crops. Except in the wettest years, when even the poorer soils are very productive, acre yields of corn are as high and those of alfalfa are higher on Cass fine sandy loam than on any soil throughout the uplands. In general, this soil comprises only a small part of the farm on which it occurs.

Included with areas of Cass fine sandy loam, and not shown separately on the soil map on account of their small size, are three narrow strips of Cass very fine sandy loam and two small areas of Cass clay loam. The areas of Cass very fine sandy loam, totaling less than 300 acres, are in the bottom lands along Niobrara River where they occur as strips 4 or 5 rods wide adjacent to the south edge of the Verdel soil terraces in Bush, Lynch, and Bristow Townships. The two small areas of Cass clay loam, with a combined area of about 160 acres, are along the State highway in secs. 16 and 21, T. 33 N., R. 9 W. The topsoil in these areas is composed largely of clay

and cannot be cultivated under so wide a range of moisture conditions as the topsoils of the other Cass soils.

Sarpy silt loam.—Sarpy silt loam occurs only in the bottom lands along Missouri River northeast of Lynch. Its total area is small.

This soil has nearly level relief and lies from 8 to 12 feet above the normal level of the river, but it is rarely subject to overflow. Both surface and internal drainage are adequate. It has developed from recently deposited stream sediments which have not yet accumulated much organic matter.

The topsoil, to a depth ranging from 8 to 10 inches, is composed largely of fine-textured sediments, chiefly silt and very fine sand. The upper 3- or 4-inch layer is slightly darker than the rest, but the topsoil, which is friable throughout, is nowhere so dark as the corresponding layer of the Cass soils and in most places is light grayish brown. The subsoil is a mixture of very fine sand and fine sand, which is loose and incoherent, except when wet. It is practically devoid of organic matter and contains scattered rusty-brown streaks and splotches. The soil, as a whole, is not high in lime but contains enough for crop requirements. The subsoil generally has a higher content of this material than the topsoil.

Practically all of this land is under cultivation and is used chiefly for corn and alfalfa. Yields of these crops average a little lower than on the Cass and Lamoure soils of the bottom lands, owing largely to the smaller content of organic matter in the Sarpy soil. The soil is well supplied with moisture, and corn and alfalfa are highly profitable even during the driest years. Some sweetclover, sorgo, and potatoes are grown, but the acreage devoted to crops other than corn and alfalfa is small.

Lamoure very fine sandy loam.—Lamoure very fine sandy loam occupies numerous narrow strips and small areas in the bottom lands along Ponca Creek. A few small bodies are along Keya Paha River and its branches.

The topsoil is dark grayish-brown or almost black friable fine sandy loam or very fine sandy loam, containing an abundance of organic matter. It averages about 12 inches thick. The fine sandy loam texture is general in only a few of the areas in Ponca Creek Valley west of Bristow. As this variation in texture does not noticeably alter the productivity or crop adaptability of the soil, the two types are not shown separately on the soil map. The subsoil consists largely of silt and clay, and it ranges from almost black to light gray but in most places is very dark. It extends to an average depth of 40 inches. Although somewhat more compact than the topsoil, the subsoil is not tough and is easily penetrated by moisture and roots. It is very limy throughout, and in places the topsoil contains a small quantity of lime.

This soil has a more limy and finer textured subsoil than any Cass soil and a darker surface layer than the Sarpy soils. It is subject to occasional overflow from the stream channels, but the surplus water drains off rapidly when the streams subside, and a negligible part of the land is too poorly drained for cultivation.

Except for strips in the smaller stream valleys, that are too narrow for profitable farming, and small patches, which are covered with forest, all this soil is under cultivation. Corn and alfalfa are the

principal crops, the former yielding an average of about 28 bushels and the latter about 2.5 tons an acre. Lamoure very fine sandy loam occupies such small bodies and narrow strips that it does not greatly enhance the total corn or alfalfa yields of the farms on which it occurs. It is a little too moist during most years for the highest yields of small grains.

Lamoure clay loam.—Lamoure clay loam occupies only a few small areas, the largest of which are in the bottom lands along Missouri River northeast of Lynch, where one comprises about 400 acres.

This soil, in common with all soils of the bottom lands, is nearly level. It lies only a few feet above the stream channels and is subject to occasional overflow, but only a small part of it is too poorly drained for the use of farm machinery.

The topsoil is very dark grayish-brown or almost black clay loam or silty clay loam. It is well supplied with organic matter and ranges from 8 to 14 inches in thickness. The subsoil is very similar to that of Lamoure very fine sandy loam.

Nearly all the land is under cultivation and, like the other soils of the bottom lands, is used chiefly for corn and alfalfa. The clayey character of the topsoil does not favor cultivation under as wide a range of moisture conditions as is possible on the more silty or sandy soils of the bottom lands. If not cultivated when too wet or dry, this soil is easily kept in good tilth. In seasons of normal or heavy precipitation corn and alfalfa yields are about as high as those obtained on Lamoure very fine sandy loam, but in dry years the topsoil of Lamoure clay loam shrinks and cracks and crops may suffer more or less from drought.

Although this soil is very productive of corn and alfalfa, it is of little agricultural importance here on account of its small extent.

SOILS WELL SUITED ONLY TO GRASS

The soils included with this group occur in all parts of the county where the lay of the land or the drainage is unfavorable for cultivation or where the soil is poorly suited to grain or tame-hay crops. The group includes the Valentine and Butler soils and the more sandy or gravelly types of the Holt, Thurman, O'Neill, and Sarpy soils. Areas of rough broken land and riverwash also are included with this group. Altogether these soils and land types make up 40.3 percent of the land area of the county.

All these soils include some cultivated land, but the greater part of each remains in its virgin state. About 90 percent of the area occupied by the group as a whole is used for native pasture and hay land.

Aside from the O'Neill soils on the terraces and Sarpy sand and riverwash on the bottom lands, all the soils in the group are on the uplands. They differ widely in topographic and soil features. The O'Neill, Sarpy, and Butler soils and riverwash have nearly level relief as a rule. The Thurman and Valentine soils range from undulating to rolling, and rough broken land is hilly.

With the exception of the Butler soil and rough broken land, both of which consist largely of dense clay, these soils are extremely sandy; several of them are composed almost entirely of fine sand to coarse sand or mixtures of sand and gravel. None of them con-

tains as much organic matter in its surface layer as commonly occurs in soils of the other groups, but the O'Neill, Thurman, Holt, and Butler soils have enough of this material to make their topsoils dark.

Rough broken land.—Rough broken land, as mapped in this county, includes areas which are too rugged to be cultivated and are of value chiefly for grazing. It has a larger total area than any soil and occupies about 30 percent of the land area of the county. It is extensive throughout the eastern part and on the steeper valley slopes along nearly all of the drainageways throughout the central and western parts. Most of it is composed of eroded phases of the Boyd soils, chiefly Boyd clay loam. In most places on the steeper slopes the topsoil is extremely thin, and in many places beds of either light- or dark-colored Pierre shale are exposed.

Practically all of this land is steeply sloping. The relief, in general, is less harsh and angular than in the areas of rough broken land so extensively developed on Tertiary sandstone in some of the western counties of Nebraska. In the Missouri River bluff lands, in the eastern part of the county, where the relief is most rugged, the surface features show an intricate network of narrow V-shaped valleys, between which some of the divides attain heights ranging from 100 to 150 feet. Most of the ridge tops, although narrow, are fairly well rounded. There are few precipitous exposures even on the steepest slopes, except in the immediate vicinity of the alluvial lands along Missouri River where erosion has cut through the Pierre formation. Here vertical bluffs of Niobrara chalk rock border the bottom lands in many places and extend for short distances up some of the tributaries of Missouri River.

Nearly all of the rough broken land is covered with a fairly dense growth of buffalo grass or grama, or a mixture of these grasses. Western wheatgrass, little bluestem, and big bluestem also are fairly abundant. The grasses will support 75 or 85 head of cattle on each section (640 acres) during the summer grazing season, May to October, inclusive. Hay is cut on gradual slopes and in pockets and coves and yields nearly one-half ton an acre during average years.

The steep slopes bordering the bottom lands along Missouri River support fairly dense mixed stands of elm, ash, hackberry, and bur oak, which are used within the county for posts and firewood.

Only a small part of the rough broken land is cultivated, although small scattered fields of corn or sorgo are on some of the more gradual slopes. These crops yield fairly well during seasons of normal or heavy precipitation, but in dry years corn, especially, returns low yields.

The value of this land, both for grazing and for the production of cultivated crops, is lowered by a small amount of selenium which occurs in soils derived from Pierre shale. It is now known that where this element, absorbed and stored by plants, is eaten by livestock, it produces what is locally known as alkali disease. Some areas of this land cause more trouble than others, but it is difficult to determine in large pastures which areas are responsible, as the malady develops slowly and the cattle range over many kinds of soil. A few pastures that have been proved dangerous have been

withdrawn from use for any purpose. This subject is discussed in a section of this report entitled "Selenium Poisoning."

Thurman sandy loam.—Thurman sandy loam occupies areas of various sizes throughout the uplands in the western, southwestern, and central parts of the county, and a few are in the eastern part. The largest body, comprising nearly 1,000 acres, is about 6 miles southeast of Butte. The remaining bodies, although numerous, are much smaller, few exceeding 320 acres.

This soil has developed in the uplands from sand deposits. Its relief ranges from nearly level to strongly undulating. Drainage channels are poorly established or absent, as nearly all of the precipitation is rapidly absorbed by the porous soil material. Internal drainage is good.

The topsoil to an average depth of 10 inches consists largely of sand but contains a small amount of silt and clay and an abundance of organic matter. The finer materials give it a loamy texture and sufficient stability to prevent destructive wind erosion, except during prolonged periods of dry, windy weather. The topsoil ranges in color from dark grayish brown to very dark grayish brown. The subsoil consists of incoherent fine sand or medium sand. It is brown in the upper 3 or 4 inches, but rapidly becomes lighter with depth and in most places is light gray below a depth of 2 feet. Both topsoil and subsoil are low in lime.

Included with this soil are a few small bodies, in which both the topsoil and the subsoil contain large amounts of gravel. These areas are indicated on the soil map by gravel symbols.

This soil differs from Thurman fine sandy loam of the first group of soils, chiefly in that it has a little coarser textured topsoil. Its subsoil contains practically no silt or clay and is more porous than the subsoil of Thurman fine sandy loam, but it is not droughty. The soil is not so unstable as most of the other soils used mainly for native pasture and hay. Because of the need for feed, about 30 percent of the land is cultivated despite its rather unstable character during prolonged dry, windy spells. The principal crops are corn, sweetclover, and sorgo, ranking in acreage in the order named. In seasons of heavy rainfall, corn sometimes yields 25 bushels an acre. Its average yield is about 15 bushels. During exceptionally dry years the crop may do better than on Moody silt loam, provided the wind velocity remains low, but in dry, windy seasons it may fail to return the seed. The average yield of sweetclover is about four-fifths of a ton and that of sorgo about 1½ tons an acre. These crops seem fairly well adapted to the sandy soil.

The uncultivated parts of this soil support a fairly thick stand of *Stipa*, or needlegrass, and big bluestem, mixed here and there with some grama. These grasses will support about 110 cattle on each square mile during the summer grazing season, or when cut for hay will yield a little over one-half ton an acre.

Thurman loamy sand.—Thurman loamy sand differs from Thurman sandy loam chiefly in that its topsoil contains less silt, clay, and organic matter and is less stable. The content of organic matter is sufficient to make the topsoil dark grayish brown to a depth ranging from 8 to 10 inches but is not enough to prevent blowing when the land is cultivated. The subsoil consists of loose gray sand.

This soil is closely associated with other Thurman soils, chiefly in the southwestern part of the county, and also occurs in a few areas in the central and eastern parts. It is the most extensive soil in the group.

Owing to its rather unstable character, this soil is poorly suited to most grain crops. The surrounding soils are still less adapted to cultivated crops, however, owing to their rolling, hummocky relief, composition of almost pure sand, and lack of organic matter. As feed crops are needed in these localities, about 20 percent of Thurman loamy sand, which is nearly level and is fairly well supplied with organic matter, is used for their production. The same crops are grown as on Thurman sandy loam. Corn and oats average only about 10 bushels an acre. Unless some sort of grass cover is maintained, the topsoil rapidly loses its organic matter through wind erosion and in cultivated fields is generally lighter in color than the topsoil in virgin areas.

The greater part of the soil remains in its virgin state and is used for pasture and hay land. It supports the same grasses as does Thurman sandy loam, but the grass cover is slightly sparser.

Valentine sand.—Valentine sand occupies one large and several small areas, most of which are between Niobrara and Keya Paha Rivers, in the southwestern part of the county.

This soil resembles Thurman loamy sand, except that it contains less organic matter, is less stable, and has more relief. The greater part of the surface is characterized by rounded hummocks and ridges, ranging from 8 to 10 feet in height, separated by shallow depressions. There is no surface run-off, as all the moisture is rapidly absorbed.

The soil consists of loose gray or grayish-brown sand to a depth exceeding 5 feet. The upper 3- or 4-inch layer is generally slightly darker than the rest of the soil but is nowhere as dark as the corresponding layer in any Thurman soil and does not contain sufficient organic matter to prevent the sand from drifting when the native sod is destroyed. The soil is very low in lime.

Valentine sand is of little value for the production of crops, and probably not over 8 percent of it is cultivated. Some corn, sorgo, and sweetclover are grown in the lower and more protected areas, where the topsoil has accumulated a little more organic matter than usual, but yields are low, except in seasons of heavy precipitation. Most of the land retains its covering of native grasses and is used for grazing cattle and the production of hay. The grasses are largely *Stipa*, or needlegrass, and sandgrass. Depending on the rainfall, these grasses will support from 20 to 25 cattle on each 160 acres during the summer grazing season. When cut for hay, they yield about one-third of a ton an acre.

Included with this soil on the accompanying map is a small body of dune sand. It occupies parts of the SW¼ sec. 4 and SE¼ sec. 5, T. 33 N., R. 16 W., and comprises about 160 acres. This body differs from areas of Valentine sand, chiefly in that it is more hilly. The sand is piled into dunes ranging from 15 to 25 feet in height. Some of the dunes have blow-outs on the northwest side, but the greater part of the sand is covered with a sparse growth of grass.

O'Neill loamy sand.—O'Neill loamy sand occupies a few large and small areas between Niobrara and Keya Paha Rivers in Basin Township, and in Ponca Creek Valley in Spencer and Butte Townships.

The land is nearly level or gently undulating. The soil is composed largely of sand, has a dark topsoil, and resembles Thurman loamy sand, except that it occurs on terraces, whereas the Thurman soil is on the uplands. The terraces range in height from a few feet to more than 100 feet above the stream channels. All the larger bodies in Basin Township are on high terraces.

Owing to its large proportion of sand, this soil is unstable when the cover of native grass is destroyed. Only about 10 percent of it is under cultivation and is planted chiefly to corn and sweetclover. Yields are a trifle higher than those obtained on Thurman loamy sand, especially those of corn, but no crop gives high yields. Sweetclover, from good stands, does fairly well in all except the driest years, but it is rather difficult to obtain a satisfactory stand of this crop on such a sandy soil.

The uncultivated parts of O'Neill loamy sand are covered with a fairly thick growth of needlegrass and sandgrass, which will support about 90 head of cattle on a section during the grazing season, or will yield a little over one-half ton of hay an acre in average years.

O'Neill gravelly sandy loam, upland phase.—The upland phase of O'Neill gravelly sandy loam occupies several small scattered areas, most of which are north of Keya Paha River in Basin Township. The largest development, comprising about 200 acres, is 1½ miles southwest of Naper. A few small bodies are in the eastern part of Ware Township and in Morton Township.

Most of this soil is on narrow ridges or on slopes around the heads of drainageways. It generally occurs within or adjacent to areas of rough broken land and is severely eroded. Part of it, lying within areas of Thurman soils, has nearly level relief.

This soil consists largely of coarse sand and water-worn gravel to a depth exceeding 3 feet. The gravel range from less than one-fourth of an inch to over 2 inches in diameter, and they become more abundant with depth. The 3- or 4-inch surface layer is, in general, dark, due to a fairly large supply of organic matter, but the remainder of the soil is brown or grayish brown.

The origin of the soil material is not clearly understood. The gravel are well rounded and probably all of them, as well as at least a part of the sand, were carried to their present position by water. Some of the sand was undoubtedly blown in by the wind. Through weathering and the accumulation of organic matter, the sand and gravel mixture has ultimately developed into a soil which is identical in all its features with O'Neill gravelly sandy loam developed on terrace material. As this soil is on the uplands instead of on the terraces, it is classed as an upland phase of that soil.

This soil is of no value for cultivated crops and is all included in pasture. It supports only a fair growth of *Stipa*, or needlegrass, and does not have a high value even for grazing. In places the gravel in the subsoil is used in concrete construction and for surfacing highways.

Holt loamy sand.—Holt loamy sand occupies a few small and widely scattered areas in Basin, McCully, and Butte Townships. The largest—about 180 acres—is 4½ miles southeast of Naper.

This soil differs from Holt very fine sandy loam of the first group of soils chiefly in that its topsoil is more sandy and less stable. It also has a wider range in relief and is a little more strongly rolling, as a rule.

The soil has developed from light-colored limy sandstone. It has a fine-textured subsoil with high moisture-holding capacity, but the topsoil, although dark, is so incoherent that when the grass cover is destroyed it blows badly. Practically all of the soil is used for pasture or hay land.

The native grasses, consisting largely of needlegrass, sandgrass, and big bluestem, do fairly well, and the soil has only a slightly lower grazing and hay-producing value than Thurman sandy loam. It is of minor importance in this county on account of its small extent.

Butler silty clay loam.—Butler silty clay loam, as mapped in Boyd County, is variable in some of its features. It everywhere has a shallow dark-colored topsoil and a heavy claypanlike upper subsoil layer.

The soil occupies scattered, shallow, and poorly drained basins within nearly level areas of the finer textured soils of the uplands and terraces, largely Moody silt loam. Water collects in all the basins after heavy rains and disappears slowly through seepage and evaporation. Few bodies of this soil exceed 80 acres, and most of them occupy only a few square rods. They are locally known as "buffalo wallows" or "lagoons."

The topsoil is a rather heavy though generally friable silty clay loam or clay loam, ranging from less than 6 to about 10 inches in thickness. It is well supplied with organic matter and is very dark, especially in the upper part. All of it contains more or less light-gray silt from which excessive moisture has leached the black organic matter, and in the more poorly drained basins or parts of basins, the lower 2- or 3-inch layer of the topsoil may be gray.

The upper part of the subsoil, which ranges in thickness from 18 to about 40 inches, is nearly black or dark grayish-brown dense clay that is almost impervious to moisture and is penetrated with difficulty by a spade or soil auger, especially when dry. The lower part, which consists of clay loam or silty clay loam, in most places is a little less dense than the overlying material and in some places is friable. It is generally light grayish brown, but almost everywhere contains rusty-brown splotches and streaks caused by imperfect drainage. It may or may not be limy, but in most places it contains an abundance of lime in finely divided form and in hard rounded light-gray concretions one-eighth to one-fourth inch in diameter. In the more poorly drained basins the subsoil and the lower part of the topsoil may contain scattered rusty-brown hard and almost round pellets or concretions one-sixteenth to one-eighth of an inch in diameter. These consist partly of iron. The material beneath the subsoil is loose friable silt or incoherent sand, depending on the locality.

Practically none of this soil is under cultivation. Even if surface drainage allowed the use of cultivating machinery, the soil would remain poorly suited for grain and tame-hay crops, because the topsoil is too thin to store much moisture and the dense clay in the

upper part of the subsoil is too poorly aerated for these crops. All the soil, except that in some of the smaller bodies which, although occurring in fields, are not cultivated, is included in farm pastures. The land supports a luxuriant growth of moisture-loving grasses and weeds. Water generally remains in the basins for several days after heavy rains, and the soil does not have much value even for grazing. It occupies only a small part of the farms on which it occurs and is of minor agricultural importance.

Sarpy sand.—Sarpy sand occupies several small bodies and narrow strips in the bottom lands or on islands along Missouri and Niobrara Rivers. Few of the areas exceed 100 acres.

The nearly level relief is modified in places by old and present stream channels, slight elevations, and shallow depressions. The land ranges from 3 to 4 feet above the normal level of the streams and, although subject to occasional overflow, is not covered with water except for short and infrequent periods.

The soil has developed from recently deposited sand which has not yet accumulated much organic matter. In places it resembles riverwash, but it is more stable and is not so greatly influenced by each slight rise of the streams. It differs from Sarpy silt loam chiefly in that it is much coarser in texture. Most of it supports a fairly dense growth of willow and cottonwood trees which are used to some extent for farm buildings, but are of value mainly for posts and fuel. Practically none of the land is farmed.

Riverwash.—Riverwash includes the material in sand bars, islands, and flats adjacent to or within the channels of Missouri and Niobrara Rivers. Only the larger areas are shown on the soil map. The material differs from Sarpy sand in that it is less stable. It lies only a few inches above the normal level of the streams and undergoes change with each slight rise of the water. Even during normal flow small areas are shifted about, added to, or destroyed by the current. The material represents the first stages of formation of alluvial soil and, when it has accumulated sufficient organic matter, will develop into Sarpy sand. Most of the land supports a fairly dense growth of seedling willow and cottonwood trees and is either included in pasture or is regarded as waste land. The sand, of which riverwash is largely composed, is much finer along Missouri River than along Niobrara River.

CLASSIFICATION OF SOIL TYPES ACCORDING TO PRODUCTIVITY

The soils of Boyd County are classified in table 6 according to their ability to produce the more important crops of this general region. This classification compares the inherent productivity of each soil for each of the leading crops in the county to a standard, namely 100, which is the rating given a soil that is inherently the most productive in the United States for the crop under consideration and which occupies sufficient acreage to warrant classing it as the standard soil for that crop. The rating (100) is called the base index and is the standard with which the productivity of all other soils for any particular crop is compared. Thus a soil estimated to be one-half as productive of a given crop as the one having the base

index rating receives an index of 50. A few unusually productive soils of small total acreage may have an index above 100 for a specified crop.

TABLE 6.—*Classification of soil types in Boyd County, Nebr., according to productivity*

Soil type [1]	Crop-productivity index [2] for—									Principal crops or type of farming
	Corn	Oats	Wheat	Rye	Barley	Alfalfa	Sweetclover	Wild hay	Pasture	
Hall very fine sandy loam	60	60	60	60	55	55	65	70	35	Corn and oats; general farming.
Lamoure very fine sandy loam (well-drained).	55	50	50	50	45	55	75	85	43	Corn and alfalfa.
Lamoure clay loam (well drained)	50	50	50	40	45	55	75	85	44	Do.
Cass fine sandy loam (well drained)	50	35	35	35	35	50	75	80	40	Do.
Moody silt loam	50	50	50	50	45	30	65	70	35	Corn and oats; general farming.
Moody very fine sandy loam	50	50	50	50	45	30	65	70	35	Do.
Marshall loam, sandy-substratum phase	50	50	50	50	45	30	65	70	35	Do.
Moody fine sandy loam	45	40	40	45	40	25	55	65	30	Do.
Boyd silt loam	45	45	45	45	45	25	55	70	35	Do.
Verdel very fine sandy loam	45	45	45	45	45	25	55	60	30	Do.
Holt very fine sandy loam	40	40	40	40	40	25	45	65	30	Do.
Verdel clay loam	35	40	40	40	40	20	45	55	26	Do.
Cass loamy fine sand (well drained)	40	30	30	35	30	45	70	75	35	Corn and alfalfa.
Sarpy silt loam (well drained)	40	35	35	35	35	45	70	70	35	Do.
Boyd sandy loam	35	30	30	35	30	20	50	60	30	Corn and oats; general farming.
O'Neill fine sandy loam	35	30	30	35	30	30	50	60	30	Do.
Thurman fine sandy loam	30	25	25	30	25	20	40	60	30	Do.
Thurman sandy loam	30	25	25	30	25	20	40	60	30	Do.
Marshall loamy sand, sandy-substratum phase.	30	20	20	25	20	20	40	60	30	Do.
Boyd clay loam	25	30	30	30	30	15	40	35	20	Do.
Boyd clay loam, light-colored phase	25	30	30	30	30	15	40	35	18	Do.
Verdel loamy sand	25	20	20	25	20	15	40	55	26	Do.
O'Neill loamy sand	20	15	15	20	15	15	35	55	26	Pasture and wild hay.
Holt loamy sand	20	15	15	20	15	15	35	55	26	Do.
Thurman loamy sand	20	15	15	20	15	15	35	55	26	Do.
Lamoure clay loam (poorly drained)	----	----	----	----	----	----	----	100	45	Do.
Lamoure very fine sandy loam (poorly drained).	----	----	----	----	----	----	----	100	45	Do.
Cass fine sandy loam (poorly drained)	----	----	----	----	----	----	----	100	45	Do.
Cass loamy fine sand (poorly drained)	----	----	----	----	----	----	----	80	40	Do.
Sarpy silt loam (poorly drained)	----	----	----	----	----	----	----	75	36	Do.
Sarpy sand	----	----	----	----	----	----	----	50	23	Do.
Valentine sand	----	----	----	----	----	----	----	40	20	Do.
Rough broken land	----	----	----	----	----	----	----	40	20	Do.
Butler silty clay loam	----	----	----	----	----	----	----	50	23	Do.
O'Neill gravelly sandy loam, upland phase.	----	----	----	----	----	----	----	----	15	Pasture.
Riverwash	----	----	----	----	----	----	----	----	10	Do.

[1] Soils are listed in approximate order of their general productivity in the county, the most productive first.

[2] Soil types inherently most productive for the specified crop in the United States are given the index 100. Only those inherently most productive soil types of significant acreage in the more widely known crop regions have been given the standard of 100. The other indexes give the approximate production in percent of the standard.

NOTE.—No ratings on grain and tame-hay crops are given to soils that are definitely unsuited for cultivation, although some areas of these soils are farmed.

The inherent productivity indexes are based on the ability of the soil to produce under a management capable of maintaining the inherent or natural level of productivity but which does not involve irrigation, terracing, drainage, or the use of fertilizers other than those produced from crops grown on the soil.

The soils are listed in the order of their general productivity, which is determined chiefly by their ability to produce the more

important staple crops. No attempt is made to group the soils best suited for specified crops or to account for differences in the quality of the crops.

As the soils in this county do not receive amendments, such as lime, phosphate fertilizer, and complete fertilizer, no rating is given to indicate their response to fertilization. The use of manure produced on the land is not considered an amendment.

The factors influencing productivity of land are mainly climate, soil, and relief, or lay of the land. As long-time crop yields furnish the best available summation of the factors contributing to soil productivity, these have been made the basis for determining the productivity indexes in this table, which are based on the average annual yields of the crops during the period 1923 to 1932, inclusive.[6]

The rather low indexes given to most of the soils in this county do not necessarily indicate that these soils are not well suited for the crops grown on them. Many of the soils are among the strongest and most productive in this section. Few of them give as high yields of a particular crop as are obtained on what is regarded as the ideal, or standard, soil for that crop, but this, in the majority of instances, is due mainly to less favorable moisture conditions and surface features, or both, than occur in the section occupied by the standard soil. Most of the soils in the county contain enough plant nutrients to insure much higher yields were moisture more abundant.

In rating the soils on the bottom lands or flood plains, two index ratings are given, one applying to the better drained areas and the other to poorly drained areas. The map, however, does not distinguish between these areas, except in localities where drainage is so poor that a marshy condition prevails the greater part of each year. Here the conventional marsh symbol is used. Elsewhere on the bottom lands the poorly drained tracts, although numerous, occupy such small patches and narrow strips that they could not be indicated legibly on a map of the scale used in this survey.

Streams occasionally overflow small local tracts on the flood plains, but no productivity ratings are given to these tracts, because overflow is of little importance in the agriculture of this county.

The table here presented is not based on enough factors which influence land use to warrant interpreting the ratings directly into specific land values. It is based on essentially permanent factors relating to the inherent productivity of the soils, and no consideration is given transitory economic factors. In some instances the information on which the ratings are based is not so complete as desired, and further study may suggest changes.

The following tabulation gives the more important crops of the county and the acre yield that has been set up as a standard of 100 for each crop. These yields represent long-time production averages of the inherently most productive soils of significant acreage in the United States for products of satisfactory quality and are obtained without the use of soil amendments other than those produced directly or indirectly by the soil.

[6] Unpublished data from the Nebraska agricultural statistics, compiled by A. E. Anderson, State and Federal statistician.

	Bushels
Corn (grain)	50
Oats	50
Wheat (all kinds)	25
Rye	25
Barley	40
	Pounds
Alfalfa	9,000
Sweetclover	4,000
Wild hay	2,000
	Cow acre-days per year [7]
Pasture	100

SELENIUM POISONING

Since the first settlement in this section of the country a disorder of livestock, including poultry, has been prevalent in certain areas along Missouri River and its tributaries in Nebraska and South Dakota. The name "alkali disease", locally given to this trouble, is a misnomer, as it has been proved that neither alkali water nor alkali salts in the soil could produce the symptoms which the affected animals exhibit.

In horses, cattle, and swine the malady manifests [8] itself by an alteration of the growth of hoofs and a loss of hair from the manes and tails of horses, and loss of the switch on cattle and of hair on swine. The condition may be mild or so severe that the animals lose their hoofs. In addition to those outward symptoms, the bones and joints are seriously affected. In severe cases animals that become lame and unable to travel die of thirst or starvation, or have to be destroyed. In poultry the malady either prevents the eggs from hatching or results in deformed chicks.

Surveys of the area where this trouble occurs show it to be widespread and everywhere associated with soils developed from Cretaceous shales. Chemical analyses of samples of soils and vegetation from the affected areas revealed the presence of selenium.[9] Further experiments have definitely proved that animals in other places contract the so-called alkali disease when fed grain grown in definite soil areas or on soils artificially treated with small quantities of selenium.

For many years it had been known that the disorder now recognized as selenium poisoning had resulted in serious damage to several farms in Boyd County and that many farmers sustained occasional losses of livestock. Intensive investigations were begun in this county in 1933 [10] to determine the quantities of selenium present in both soil and vegetation and the extent of the areas involved. A number of samples of the soil, the underlying shale, and the plants growing on the soil were taken in selected localities. Transects were made along nearly all the roads in the affected areas, and samples

[7] Cow acre-days is a term used to express the carrying capacity of pasture land. It is the numerical equivalent of the number of animal units supported by 1 acre during a given period of days.

[8] FRANKE, K. W., RICE, T. D., JOHNSON, A. G., and SCHOENING, H. W. REPORT ON A PRELIMINARY FIELD SURVEY OF THE SO-CALLED "ALKALI DISEASE" OF LIVESTOCK. U. S. Dept. Agr. Circ. 320, 10 pp., illus. 1934.

[9] ROBINSON, W. O. DETERMINATIONS OF SELENIUM IN WHEAT AND SOILS. Jour. Assoc. Off. Agr. Chem. 16: 423–424. 1933.

[10] BYERS, H. G. See footnote 5, p. 13.

were taken at regular intervals. The soil and vegetation on several farms where the malady had been reported were sampled at intervals of a few hundred feet in several directions, in order that the distribution of the selenium might be mapped with accuracy.

The investigations show that harmful quantities of selenium are present only in those soils derived from Pierre shale or from materials washed directly from these formations. Such soils are classed with the Boyd and Verdel series. In places these soils are extremely toxic. The large areas of rough broken land along Missouri River and its tributaries nearly everywhere have a thin soil covering which has been developed from Pierre shale and overlies the shale. This land, except the very toxic areas, which have been abandoned, is used for pasture.

Selenium occurs generally in all soils derived from Pierre shale, but the amount varies widely from place to place. The content of selenium is not uniform in plants of the same species growing in different localities, and plants of different species show a wide range in their power to absorb and accumulate the toxic element.

No practical measures of soil treatment have been discovered to reduce the losses caused by selenium poisoning. Several medicines, given animals to counteract the toxic effects of foodstuffs grown in affected areas, have been tested and found to be of no value. The only advice that can be given the farmer is to ascertain, if possible, which of his fields are most toxic and discontinue their use as farm land or pasture.

Additional detailed information on this subject can be obtained from the publications cited.

MORPHOLOGY AND GENESIS OF SOILS

Boyd County is near the northern part of the Chernozem soil region of the United States. The soils have developed under mid-continental climatic conditions characterized by high summer and moderate to low winter temperatures. The mean annual precipitation, as recorded at Butte in the central part of the county, is about 22 inches. Most of it falls during the spring and summer. The relative humidity is fairly regularly about 70 percent. Such a climate has favored the growth of a luxuriant grass vegetation. Forests occur only in narrow strips and generally in thin stands on the bottom lands and valley slopes along the larger streams. Organic matter from decayed grass roots has given all the soils, except those developed from the most recently exposed or deposited geologic materials, dark topsoils. Some of the soils in the areas of recently exposed geologic materials also have dark surface soils, but their color is derived from the darker beds of Pierre shale from which they have developed, not from accumulation of organic matter.

The rainfall has been sufficient, except in areas where run-off is rapid, to remove the readily soluble salts from the surface soils, but the downward-moving water, especially in the finer textured soils, has been able to carry the dissolved material only a short distance into the subsoil. Here the less soluble salts, chiefly lime carbonate, have accumulated, forming a layer with a higher content of lime than occurs in any other part of the soil profile. This lime carbonate horizon is present in all the finer textured and less erosive

soils of the uplands and terraces at a depth ranging from 2 feet in the more clayey soils to about 5 feet in the silty or slightly sandy soils. The coarser textured soils of the uplands and terraces, including those in which sand or gravel lies above the depth of penetration of moisture, are thoroughly leached of their carbonate to a depth exceeding 8 feet.

In addition to the prevailingly dark color of their topsoils and the development of a lime zone in their subsoils, all the older and more nearly mature soils of this county have finely granular surface layers, friable upper subsoil layers with well-developed prismatic cleavage, and friable, cloddy, or massive lower subsoil layers. Some soils, which have developed from the extremely heavy Pierre shale formation, are clayey and dense throughout, but the only soil in the county having a pronounced claypanlike layer in its subsoil is Butler silty clay loam which occupies only a small total area.

Surface drainage is good on all soils except the Butler, which has developed in poorly drained depressions on the uplands, and on soils in local spots on the bottom lands. Areas of rough broken land and most areas occupied by the Boyd soils, are subject to rapid surface run-off and, where not protected by vegetation, suffer severe erosion. Internal drainage, except in the Boyd, Verdel, and Butler soils, and on parts of the bottom lands, is thorough.

The most extensive and among the most nearly mature soils in the county are the Moody soils. They have developed from light-colored limy and silty loess which thinly caps most of the higher and more nearly level parts of the uplands. These soils have good but not excessive surface and internal drainage and have lain in their present positions undisturbed by destructive erosion probably ever since deposition of the loessial material.

Following is a description of a profile of Moody silt loam observed on the smooth uplands in the NW¼ sec. 31, T. 34 N., R. 10 W.:

1. 0 to 1½ inches, grayish-brown mellow very fine sandy loam.
2. 1½ to 3 inches, very dark grayish-brown faintly laminated friable silt loam.
3. 3 to 8 inches, friable faintly granular material of about the same texture and color as that in the layer above. The granules, few of which exceed one-eighth inch in diameter, are rather angular and very fragile. Many of them are poorly developed.
4. 8 to 16 inches, the material is slightly lighter in color than in the overlying layer with slightly larger and firmer granules.[11]
5. 16 to 40 inches, moderately compact grayish-brown silty clay loam. This is the layer of maximum density, but the compaction is scarcely noticeable except by comparison with the other layers. The material appears massive when moist but on drying cracks vertically into prisms, especially in the upper part, the prisms averaging about 2½ inches in diameter.
6. 40 to 52 inches, light grayish-brown floury silt containing an abundance of concretionary and finely divided lime. This is the layer of maximum carbonate enrichment, or the lime zone. Most of the concretions are nearly round. They average about three-sixteenths of an inch in diameter.

Beneath the lime zone is gray or grayish-brown incoherent sand. The sand does not contain sufficient lime to react noticeably with dilute hydrochloric acid, except in a thin layer which is in contact with the lime zone. It apparently has little influence on the char-

[11] No soil in Boyd County has such pronounced granulation as occurs in the well-developed soils of eastern and southeastern Nebraska and throughout Iowa.

acter of the soil, which is developed entirely from the overlying loess.

All transitions in color and texture between the different layers of the profile are very gradual. The organic matter, which is abundant in the surface layers, gradually decreases downward. To a depth of 8 inches it is evenly distributed throughout the soil mass, but below this depth it occurs chiefly as a film or coating on the surfaces of the structure particles. The film practically disappears a few inches above the lime zone. Insect casts are abundant in that part of the profile between the faintly laminated layer and the lime zone. Borings are especially numerous in the layer of maximum density. They consist of crooked rodlike soil forms about three-eighths of an inch in diameter and of various lengths. Most of them are slightly lighter or darker in color than the surrounding matrix. They probably represent fillings in old root, worm, or insect holes.

The profile described is similar in its major features to that of all the nearly mature soils of this county. It is almost identical with the profile of Hall very fine sandy loam. The Hall soil, however, has a slightly coarser textured topsoil than Moody silt loam and occupies terrace or bench positions, whereas the Moody soil is on the uplands.

The Marshall soil as mapped here is not typical of Marshall soils in more eastern counties of Nebraska and in Iowa. It has developed from upland loess similar to that from which the Moody soils and the more eastern Marshall soils are derived, but in this county it occurs only where the loessial material is unusually thin and rests on sand within a depth of 3 feet. The topsoil is as dark and thick as in any Moody soil. The upper part of the subsoil is grayish-brown friable silt loam with prismatic structure, and the lower part is almost white floury silt. The entire soil profile is above the average depth of penetration of moisture and has been thoroughly leached of its carbonates.

Scattered throughout the more nearly level parts of the Moody and Marshall soils are many small basinlike depressions occupied by Butler silty clay loam. Water accumulates in the basins after rains and in many of them remains on the surface of the ground for several weeks. Excessive moisture has greatly influenced the character of the soil. The topsoil is friable or only slightly compact and in most places not more than 8 inches thick. It is variable in structure but is generally more or less laminated and in very few places contains much granular material. The upper one-half or three-fourths of this layer is almost black but is invariably sprinkled with nearly white silt particles from which the organic matter has been leached. The lower part of the topsoil may or may not be dark. Its color depends on the degree of leaching and ranges from almost black to white. Where very light in color, the material generally is laminated.

The subsoil is a true claypan. It ranges in thickness from 18 inches to over 4 feet and in color from almost black to dull gray. The thicker and lighter colored claypans are in the deeper and more poorly drained basins or parts thereof and contain many rusty-brown spots, specks, and splotches. The high content of clay in this layer is due largely to colloidal material transported from the topsoil.

A lime zone may or may not lie beneath the claypan, but generally does, especially in areas where the dense clay is less than 30 inches thick. It averages about 14 inches thick and consists of floury light-gray silt, in which the lime is chiefly in small rounded concretions. Beneath the lime zone is gray sand or mixtures of sand and gravel. Almost round ferruginous pellets from one-eighth to one-fourth inch in diameter, are in the claypan, especially in the more poorly drained localities.

The Thurman, O'Neill, and Valentine soils are composed almost entirely of sand and have been leached of their carbonates. None of them has sharply defined textural horizons, although the Thurman and O'Neill soils have dark surface soils and brown upper subsoil layers.

The Holt soils have developed from light-colored fine-grained loosely indurated sandstone of late Tertiary age, which has been exposed to weathering through the removal of the overlying deposits of sand, gravel, and loess. These soils have dark surface layers, except on the steeper hillsides, but the subsoils have not been greatly influenced by soil-forming processes. In most places the layers or horizons are not so well defined as those in the Moody soils. In many places fragments of the parent sandstone occur at slight depths.

The Boyd soils on the uplands and the Verdel soils on terraces, have developed from the Pierre shale formation of late Cretaceous age. This formation consists of almost black to nearly white heavy shale which contains numerous seams and cracks generally filled with finely divided lime but here and there with gypsum. The soils derived from this shale have imperfectly developed and, in most places, dense subsoils. They are highly calcareous. A well-developed lime zone is not common but where present generally lies at much slighter depths than in the Moody soils. The surface layer of the Verdel soils is very dark, but in the Boyd soils it ranges from light to dark, depending on the slope, the severity of erosion, and the color of the underlying shale.

The soils on the bottom lands are derived from recently deposited alluvium which has not developed horizons or layers of true soil character. The more sandy soils are classed with the Cass and Sarpy series and the more silty ones with the Lamoure series. The Cass and Lamoure soils have accumulated much organic matter and have dark surface layers. The Sarpy soils are light colored throughout.

SUMMARY

Boyd County, Nebr., lies on an eroded formerly nearly level to hilly plain. Most of the smoother and higher plain remnants are thinly capped with loess, and a few nearly level to rolling areas, mainly in the western part of the county, are covered with sand. In the eastern part and along the sides of valleys throughout the central and western parts, geologic erosion has removed most of the covering of loess and sand which originally made up the surface soil and has produced a generally strongly rolling to hilly relief over the underlying Pierre shale formation.

Alluvial lands, including terraces and flood plains, occupy about 15 percent of the county. They occur chiefly along Missouri and

Niobrara Rivers, which bound the northeastern and southern sides of the county, respectively, and along Keya Paha River and Ponca Creek.

The native vegetation is predominantly grass. Forest trees grow only in narrow strips and rather thin stands in the valleys of the larger streams. The leading grasses on the hard lands are grama, buffalo grass, and wheatgrass, whereas on the sandy lands *Stipa*, or needlegrass, and sandgrass predominate.

Well water varies in quantity and quality. Most of the wells in the loess- and sand-covered areas furnish an abundance of good water, but well water in the Pierre shale areas is scarce and alkaline. Springs, most of which furnish water of good quality, occur on the lower valley slopes along the rivers and Ponca Creek.

The climate is characterized by rather high summer and moderate to low winter temperatures. The mean annual precipitation is 22.19 inches, and the mean annual temperature is 47.8° F. The relative humidity is rather regularly about 70 percent.

According to the Federal census, crops were harvested on about 49 percent of the land in this county in 1929, and about one-fifth of the harvested acreage was used for the production of wild hay. Most of the uncultivated land was included in native pasture.

The farming system is in general diversified; the total value of crops is about equal to that of the domestic animals during most years. Practically all of the crops, except wheat, which generally is sold for cash, are used in feeding livestock, mainly cattle and hogs, which are the chief sources of revenue. Corn has been and still is the leading cultivated crop. Other crops include oats, alfalfa, wheat, sweetclover, barley, rye, sorgo, and millet, ranking in acreage in about the order named during most years.

The soils range from moderately to highly productive of the crops for which they are used. They differ widely in their crop adaptabilities, however, according to differences in their composition and relief. All, except those developed on the most recently exposed or deposited geologic materials, have dark surface layers, owing to an abundance of organic matter. The more extensive soils have friable and moderately fine textured topsoils and subsoils, with high moisture-retaining capacities. Rather large areas of soils, especially in the western part of the county, are composed chiefly of incoherent sand. In the eastern part, most of the soils consist mainly of clay derived from the heavy Pierre shale formation and have moderately to extremely compact topsoils and subsoils. None of the soils seems to be deficient in lime, so far as crop needs are concerned, and most of them contain an abundance of this material in their subsoils.

The individual soils of the county are grouped, on the basis of the crops for which they are most extensively used and for which they give the largest returns under the present farming system, as follows: (1) Soils suitable for the production of corn and oats; (2) soils suitable for the production of corn and alfalfa; and (3) soils well suited only to grass.

The soils suitable for the production of corn and oats include the darker, more friable, and more stable soils of the uplands and terraces. All have good surface and internal drainage, and most of them have a high moisture-holding capacity. They are adapted to

all crops commonly grown in the county. The Moody and Marshall soils of the uplands and the Hall and Verdel soils on the terraces are representative of this group. The first three named have developed from loess and loesslike material, and the Verdel soils have developed from clay derived from the Pierre shale formation. They are rather compact, especially in their subsoils. The Moody soils are the most extensive in the county.

The soils suitable for the production of corn and alfalfa include all the soils on the bottom lands, except Sarpy sand which is extremely sandy and contains little organic matter. They occupy only a small proportion of the total area of the county, but, owing to their good supply of moisture, are more productive of corn and alfalfa than any soil of the uplands or terraces and are used chiefly for these crops. This group comprises the Cass and Lamoure soils and Sarpy silt loam. The first two named have an abundance of organic matter in their surface layers, which are very dark. The Lamoure soils are fine textured throughout, whereas the Cass and Sarpy soils have sandy subsoils. The Sarpy soil contains little organic matter and is fairly light colored. None of the soils on the bottom lands is well suited to small grains.

The group of soils well suited only to grass includes those which are so sandy, clayey, or poorly drained, or have such rough relief that they are unsuited to cultivation. Valentine sand, Butler silty clay loam, and the more sandy or gravelly types of the Holt, Thurman, O'Neill, and Sarpy soils belong in this group. Extensive areas of rough broken land and small bodies of riverwash also are included. These soils and land types commonly are not so well supplied with organic matter as the soils of the other two groups. Most of them contain a sufficient amount of organic matter, however, to have fairly dark topsoils. The Valentine, Thurman, Holt, O'Neill, and Sarpy soils of the group are composed chiefly of sand, and, with the exception of Sarpy sand, which is on the bottom lands where moisture is abundant, are rather unstable under cultivation. The Butler silty clay loam soil of this group is composed largely of clay, is very poorly drained, and has an extremely dense subsoil. Although none of these soils is well suited to tame-hay or grain crops, most of them support a good cover of native grass, on which cattle raising depends.

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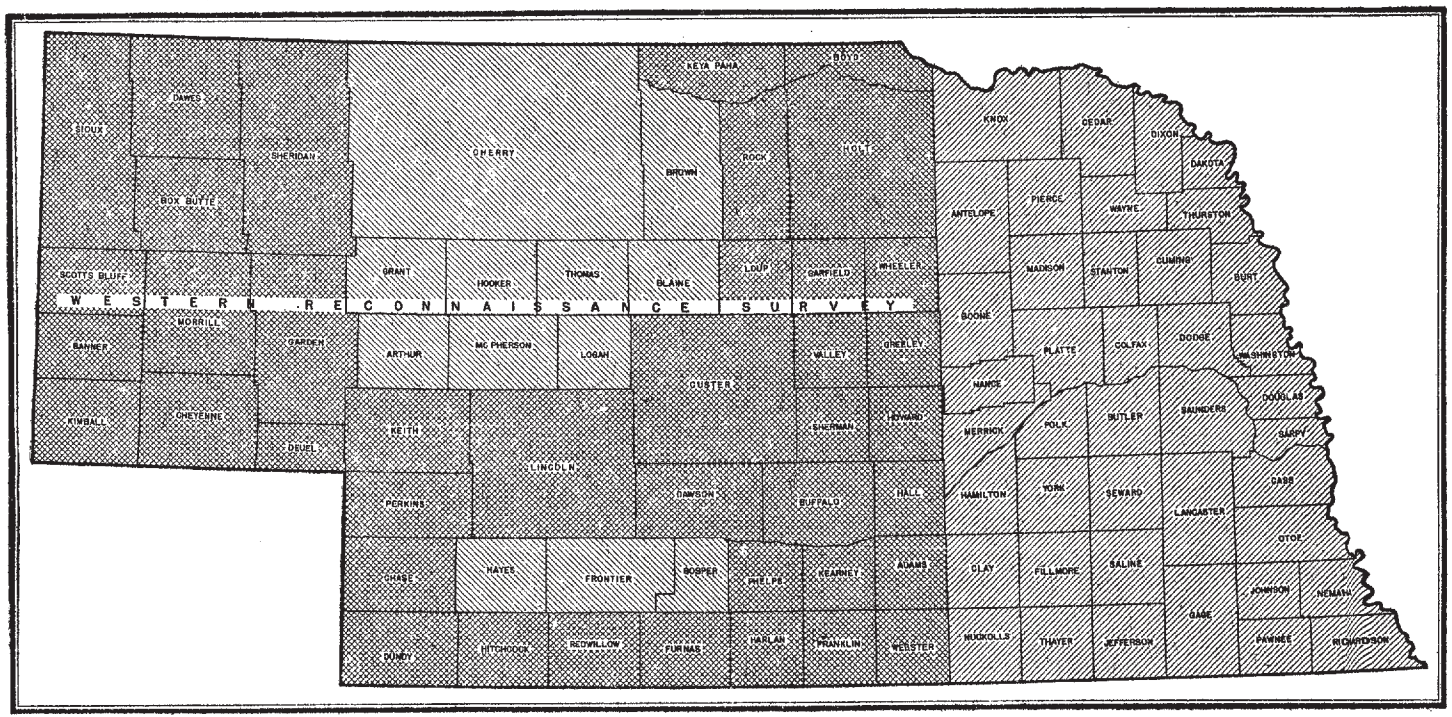
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KEYA PAHA
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FURNAS
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DUNDY
CHASE
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DEUEL
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SOIL MAP
BOYD COUNTY
NEBRASKA

UNIVERSITY OF NEBRASKA
STATE SOIL SURVEY DEPARTMENT OF THE
CONSERVATION AND SURVEY DIVISION
G. E. CONDRA, DEAN AND DIRECTOR

R. 16 W.
R. 15 W.
R. 14 W.
R. 13 W.
R. 12 W.
R. 11 W.
R. 10 W.
R. 9 W.
GREGORY CO.
BOYD CO.
SOUTH DAKOTA
NEBRASKA
T. 35 N.
T. 34 N.
T. 33 N.
T. 32 N.
W A R E
M c C U L L Y
B A S I N
M O R T O N
M U L L E N
B U T T E
S P E N C E R
B R I S T O W
L Y N C H
B U S H
KEYA PAHA CO.
KNOX CO.
HOLT CO.
CHARLES MIX CO.
NIOBRARA
MISSOURI
RIVER
Naper
Butte
Spencer
Bristow
Lynch
Monowi
CONVENTIONAL SIGNS
CULTURE
DRAINAGE
LEGEND
Boyd sandy loam — Bl
Butler silty clay loam — Bu
Holt loamy sand — Hl
Marshall loamy sand, Sandy-substratum phase — Ml
Moody silt loam — Ms
Sarpy sand — Ss
Thurman fine sandy loam — Tf
Verdel loamy sand — Vd
Boyd silt loam — Bo
Cass loamy fine sand — Cs
Holt very fine sandy loam — Ho
Marshall loam, Sandy-substratum phase — Ma
O'Neill loamy sand — Os
Sarpy silt loam — Sl
Valentine sand — Vs
Verdel very fine sandy loam — Vf
Boyd clay loam — By
Cass fine sandy loam — Cl
Lamoure very fine sandy loam — Lv
Moody fine sandy loam — My
O'Neill gravelly sandy loam, Upland phase — Og
Thurman loamy sand — Tl
Riverwash — Rv
Verdel clay loam — Vc
By — Light-colored phase
Hall very fine sandy loam — Hv
Lamoure clay loam — Lc
Moody very fine sandy loam — Mv
O'Neill fine sandy loam — Of
Thurman sandy loam — Ts
Rough broken land — Rb
Scale 1 inch = 1 mile

Thomas D. Rice, Inspector, District 3.
Soils surveyed by W. J. Moran, in charge, and F. A. Hayes, U. S. Department of Agriculture, and R. H. Lovald, Nebraska Soil Survey.

Field Operations
Bureau of Chemistry and Soils
1933